MAY, 1959

Welding Journal

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VOLUME 38 • NUMBER 5 • MAY 1959

Welding Journal

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PRESS-TIME NEWS ...about ...People ...Welding ...Products

Papers Selected for Presentation at 1959 AWS National Fall Meeting in Detroit

In resuming its policy to hold a national meeting in the fall of each year, the AMERICAN WELDING SOCIETY will headquarter this year in Detroit's Sheraton-Cadillac Hotel from September 28th through October 1st. During this week, 48 technical papers will be presented. The 1959 AWS National Fall Meeting will feature a well-balanced program that has been selected by the AWS Technical Papers Committee. Keeping in tune with the more specific interests of the Motor City, two sessions, comprising a total of six papers, will be supplied by the AWS Automotive Welding Committee. One of these sessions will concern resistance welding, while the other will involve arc welding and welding design.

The four-day program will feature several new categories which reflect advances made in the welding industry. Separate sessions on process development, nondestructive testing, titanium, tantalum, beryllium and other alloys should provide added interest to this fall's meeting. Also, a second session on resistance welding is scheduled. Rounding out the program will be two sessions each on toughness in steel weldments and welded structures, while single sessions will cover brazing, inert-gas welding, weldability of steels, aluminum and weldments.

The 1959 National Fall Meeting will be strictly a technical program. There will be no welding show. The detailed technical papers program will be published in the June issue of the WELDING JOURNAL.

Linde President Predicts Oxygen Rise

William M. Haile, president of Linde Co., recently stated that oxygen production in the United States is expected to exceed 80 billion cu ft in 1959. Speaking to a group of Linde distributor salesmen attending a sales training course at Linde's Speedway Factory and Laboratory in Indianapolis, Mr. Haile said this projection indicated a rise of about 20 billion cu ft over last year's output.

Mr. Haile expressed the opinion that welding supply distributors will handle a considerable amount of increased oxygen business as well as greater sales of other products. He predicted his company's distributor sales of oxygen, other industrial gases and apparatus will rise from 8 to 10% above last year's sales.

Contracts Awarded for United Engineering Center

Turner Construction Co. of New York has been named as the general contractor for the new United Engineering Center, future headquarters for the AMERICAN WELDING SOCIETY. The Center will be erected on the west side of the United Nations Plaza between 47th and 48th Sts. in New York.

Architects for the new Center are Shreve, Lamb and Harmon Associates; the structural engineers are Seelye, Stevenson, Value and Knecht; and the mechanical engineers are Jaros, Baum and Bolles.

Willis F. Thompson, vice-president of Westcott and Mapes, consulting engineers of New Haven, Conn., is chairman of the real estate committee of UET, which will have general supervision of design and construction of the new building.

Space has been set aside in the building for educational exhibits which will dramatize the creative role of engineers in advancing world living standards. The metal, glass and limestone structure, fully air-conditioned, will occupy a site of 37,000 sq ft.

Welded Hulls Cited by Danish Shipowner

A UPI news release with the dateline of "Copenhagen, Jan. 31" was published in the Feb. 1, 1959 edition of the *Los Angeles Times*. The important details of this article are published herein.

"A Danish shipowner who two years ago warned that the *Hans Hedtoft* should not sail on the Greenland run refused to comment tonight on the missing vessel which hit an iceberg yesterday.

" 'If there is a person today who ought to keep silent, then it is me,' shipowner Knund Lauritzen said.

"Lauritzen was the most outspoken critic of the *Hans Hedtoft* in a bitter controversy among Danish shipping experts when the Greenland Trading Co. announced two years ago she would be built as the flagship of its fleet.

"At the time, Lauritzen warned that the *Hans Hedtoft*, with her riveted hull, was likely to run into trouble on the iceberg-strewn route between Copenhagen and Greenland.

"He contended ships designed for the route should have all-welded hulls with the plates welded to the frame. He warned a riveted hull was likely to burst under any major ice pressure."

AWS Elects New Officers

Charles I. MacGuffie has been elected president of the AMERICAN WELDING SOCIETY for the 1959–60 term. He will assume office on June 1, 1959, succeeding the current president, G. O. Hoglund.

The complete results of all elections are published on Page 485.

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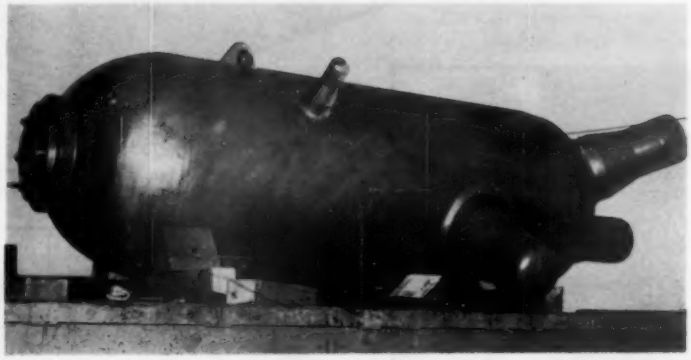
WELDING ZONES

This type of automatic installation, utilizing submerged-arc welding equipment, is spurring the high-speed fabrication of huge pressure vessels. Here, a submerged-arc welding head, welding flux and carbon-steel wire are used to join an end in a mild-steel reaction vessel at a speed of 15 ipm. (Courtesy of Linde Co.)

A new research program at Southwest Research Institute, San Antonio, Tex., is aimed to improve design and efficiency of nuclear boilers and other pressure vessels. To date, such pressure vessels have been overdesigned due to the absence of adequate information on the necessary limits for safety. This program, jointly sponsored by the AEC and the Pressure Vessel Research Committee of Welding Research Council, is expected to reduce weight and cost in future fabrications of this nature



Ten miles of wrought-iron pipe, 1 in. in diam, fully welded, have been fabricated into an ammonia-brine circulation network system in this new ice rink at Boston College. The entire piping system has been embedded in a concrete slab and then surfaced with terrazo at the New England school's new $1 million McHugh Forum. (Courtesy of A. M. Byers Co.)

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WORLD-WIDE WELDING NEWS

By Gerard E. Claussen

WEST GERMANY

Automatic "Firecracker" Welding Process Described

The automatic welding of pipe by the Gunther "firecracker" process is extensively and technically described in the October 1958 issue of *Schweissen und Schneiden*. Included in the description are the electromagnetic principles and the results of radiographic, metallographic and mechanical testing. It is stated that further developments have made it possible to complete 100 pipe joints in 10 hr in diam up to 35 in., using two to four arcs simultaneously on the same joint. Alternating current is preferred, with E6010-type electrodes for root passes and E6013 electrodes for filler and cover passes.

Rotational Speed Maintained in D-c Motor-generator Welding Machine

A circuit is described in the October 1958 issue of *Schweissen und Schneiden* which maintains a constant to less than 3% rotational speed of d-c motor generators for arc welding, despite variation in line of voltage from 70 to 120% of rating. The tendency for the speed to increase with acceleration in line voltage is counteracted by a relay, rectifier and supplementary field to provide additional excitation.

Adhesive Bonding Reported

A comprehensive article on adhesive bonding of metals, wood, rubber and other nonmetallic materials appeared in the November 1958 issue of the West German *Schweissen und Schneiden*. Procedures are given both for preliminary surface preparation and for bonding. Stress-strain curves are presented for joints between steel and aluminum, and for other combinations. Lap joints equal in strength to aluminum alloy (55,000 psi) have been made. There is a bibliography of 63 articles.

DR. GERARD E. CLAUSSEN is associated with Arcrods Corporation, Sparrows Point, Md.

Hydrogen Content Evaluated

The relation between the hydrogen content of mild-steel weld metal and ductility and fisheyes in the tensile test was investigated in the December 1958 issue of *Schweissen und Schneiden*. Hydrogen content and tensile properties were measured at intervals up to 100 days after welding with four electrodes: E6020, E6015, fluid E6013 and viscous E6013. As the hydrogen content fell during storage at room temperature, the proportion of the surface of tensile fractures occupied by fisheyes decreased with E6012 and fluid E6013 electrodes. There was no improvement in ductility with the viscous E6013 electrode, although the hydrogen content decreased to the same as the fluid E6013 electrode. The low-hydrogen deposit had high ductility and low-hydrogen content throughout the period of storage.

SOVIET UNION

New Electrode Produced for Welding Cast Iron

Described in the October 1958 issue of *Svarachnoe Proizvodstvo* is an electrode with fluoride-carbonate coating and a core rod containing 45–50% nickel, with the balance iron, for welding cast iron without preheat. The weld metal contained 0.25 to 0.35% C, 5.0 to 5.5% Si, 0.2 to 0.30% Mn, 0.02 to 0.024% S, 0.02 to 0.03% P, and 48 to 50% Ni. The silicon formed a eutectic with carbon which prevented hot cracking.

Russians Cover the Welding Gamut

The December 1958 issue of *Svarachnoe Proizvodstvo* contains a discussion of the efficacy of adding braces and of prebending the components of a rigid frame to reduce deformation due to welding.

Seven other articles of interest were also included in the issue.

Another article treats power supplies for manual and automatic welding. A rising characteristic rectifier is described with which the operator can select characteristics from 50 to 190 amp per v from 25 to 150 amp. A block diagram is given to insure uniform rotational speed of the wire-feed motor despite threefold changes in current.

The fatigue strength of welded plate girders with a butt weld at the section of maximum stress depended on whether the web was welded after the flange. If the web was welded first, the fatigue strength was 25,000 psi; if the flanges were welded first, it was 30,500 psi at 2 million cycles. Submerged-arc welding with 380 to 420 amp was used and the girders were 20 ft long and 12 in. high with $4^{3}/_{4}$- x $^{5}/_{8}$-in. flanges.

Heat and material balances are drawn for the cutting of steel 0.20 and 4 in. thick with oxygen. As the proportion of unoxidized iron rises, the slag becomes difficult to detach from the lower edge of the cut.

A new regulator for oxyacetylene

SWITZERLAND

Bed plate for ship motor. (Courtesy of IIW)

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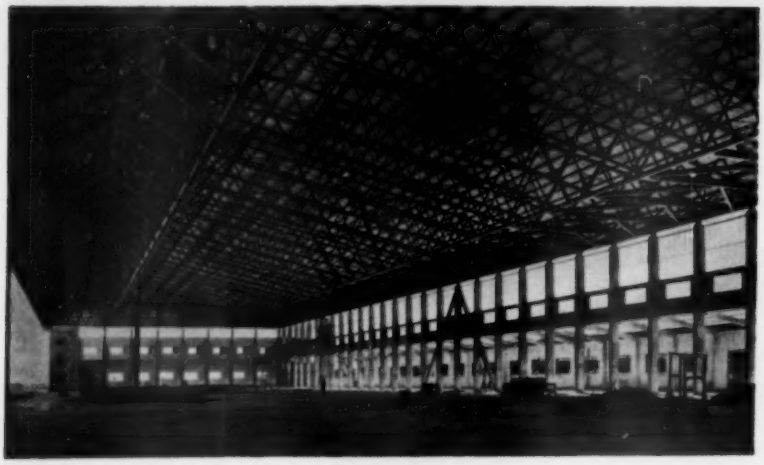
SPAIN



Aviation hangar at Barajas. (Courtesy of IIW)

welding torches is described.

The electro-slag welding of austenitic stainless-steel rings 3 to 9 in. sq at 2300 amp is described. The weld contained 0.10% C, 1.05% Mn, 0.50% Si, 17.5% Cr, 9.2% Ni, 0.1% Ti, 0.021% P and 0.010% S, and had an impact value of 16 ft-lb at −292° F.

Multi-electrode submerged-arc surfacing with mild-steel electrodes is described. Aluminum is used as a deoxidizer either as ferro-aluminum in the flux, or as an auxiliary electrode.

A new platen-control mechanism is also described for flash welding austenitic steel tubing.

Backing Rings with Clearance Used in Deep-groove Welds

The avoidance of cracks at the root of deep-groove welds in high-tensile steel gas-turbine rotors was achieved by Toropov as disclosed in the October 1958 issue of *Svarachnoe Proizvodstvo*. A backing ring with $^{5}/_{64}$-in. clearance was substituted for the usual tight-fitting ring. This solution applied to austenitic electrodes. However, the author believed that the avoidance of a tight backing fit would prevent cracking in any type of restrained deep-groove weld.

Strip Electrodes Incorporated in Electro-slag Welding

Electro-slag welding of thick sections of steel with strip electrodes is used extensively in Russia, according to an article in the November 1958 issue of *Svarachnoe Proizvodstvo*. The strips are $3^{1}/_{2}$ to 8 in. wide and 0.32 to 0.79 in. thick. The depth of molten slag is $1^{3}/_{16}$ in., the width of gap being $^{3}/_{4}$ to $1^{5}/_{8}$ in. The strips make it unnecessary to use an oscillating head. Graphs are given to establish the proper current, voltage and electrode feed rate.

CZECHOSLOVAKIA

Seven Nations Represented at Metallurgical Meeting

Bratislava was the site for another conference, this time on Welding Metallurgy, during October 1958. Organized by the Czech Academy of Science, the Czech Welding Institute and the Czech Science and Technology Society, it was attended by 110 delegates from plants, colleges and research institutes. Visitors arrived from Germany, Austria, Belgium, Poland, Hungary and Russia. In his opening address J. Cabelka, director of the Welding Research Institute in Bratislava, emphasized the importance of resistance welding to the metallurgist in solving his problems. Submerged-arc welding permitted the surfacing of steel mill rolls, thereby prolonging their life indefinitely. The problems inherent in producing heavy forgings were eliminated with electro-slag welding of heavy plates. A paper on new Russian submerged-arc fluxes stated that relatively low temperatures were used for sintering, and viscosity was adjusted by adding alumina or other high melting oxides. A study of porosity in steel weld metal under magnetic fields up to 800 oersteds led to the conclusion that porosity was not decreased by magnetic fields, despite the diamagnetism of the gases. Belgian research on steels resistant to brittle fracture, using the cross-shaped biaxial specimen, was outlined by a representative of the Liege Institute for Metallurgical Research. Two additional papers discussed developments in oxygen cutting.

Electro-slag Process Featured at Welding Conference

Papers presented at a welding conference in Brno, Czechoslovakia, in April 1958 have been published in the September-October 1958 issue of *Zvaranie*. Three papers covered electro-slag welding, describing the automatic machines developed for this process at Bratislava Welding Institute. Also described was a special submerged-arc welding machine for welding tubes to headers or tube sheets. Some of the metallurgical problems at the Lenin Works in Pilsen in welding steels for power plants are enumerated, including T56L, an alloy containing 0.17% C, 0.78% Mn, 0.29% S, 0.44% Mo, 1.37% Cr, 0.55% W and 0.79% V. An electrode depositing 0.09% C, 0.90% Mn, 0.45% Si, 0.55% Cr, 1.20% Mo and 0.35% V joined the T56L alloy, the S curve for which was determined. Four 5% Cr steels were discussed, one containing 0.86% W, while another contained 0.48 to 0.66% Mo. Another article discussed preheating and heat treatment of 12% Cr steel. Other articles featured tests on Ni-Cr alloys, one of which contained 63% Ni, 18% Cr, 13% Fe, 1.3% Si, 1.3% Mo and 1.7% W, plasma-jet cutting and friction welding.

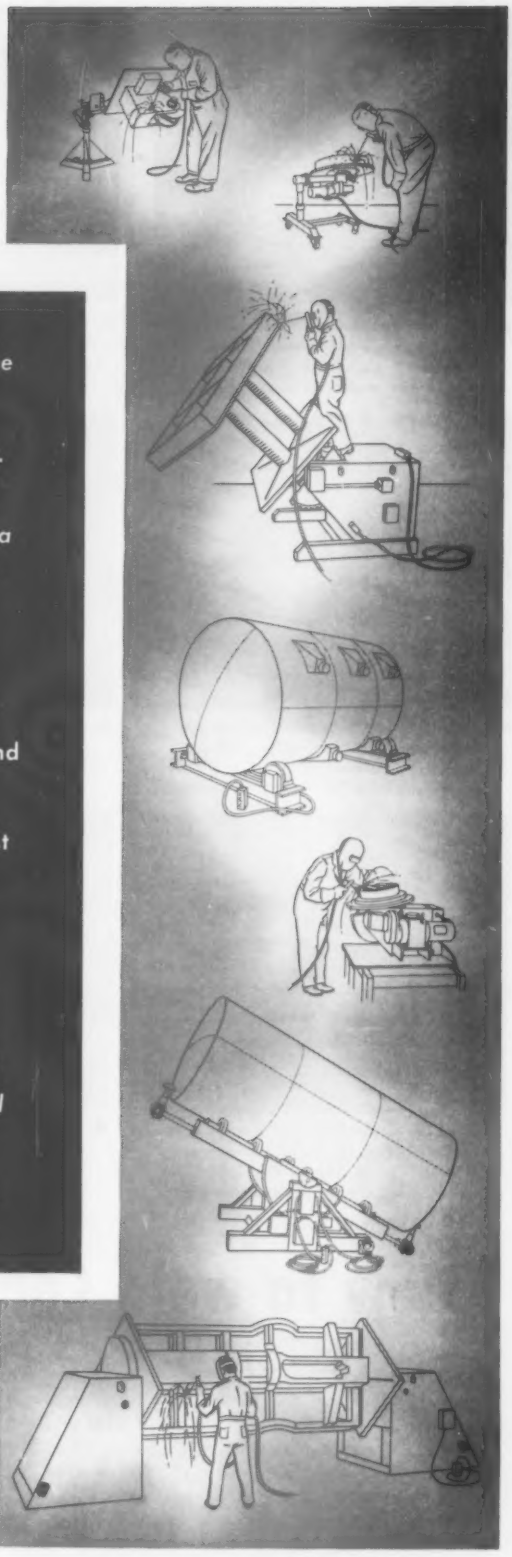
ITALY

Radiography and Gas-shielded Welding

Rivista Italiana Della Saldatura for July-August 1958 describes a slide rule for computing exposure time in industrial radiography.

The welding of a Kittel tower, 8 ft in diam and 25 ft high, is described in the September-October 1958 issue of the Italian magazine. The steel was mainly 0.28 in. thick and was welded principally by the consumable-electrode gas-shielded process. Attachments were welded with Type 310 electrodes, and the vessel was heat treated at 1400–1440° F.

POSITIONEERING *with* Aronson



In a board walk the largest item of expense is the lumber; in a splendid violin the least item of expense is the lumber.

In a plain wall the stone is the chief cost; in a piece of classic statuary the cost of the stone is hardly reckoned.

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1. After beveling both copper and type 347 stainless steel to provide an 80° included angle, ⅜-in copper specimen is pre-heated to about 1000°F.

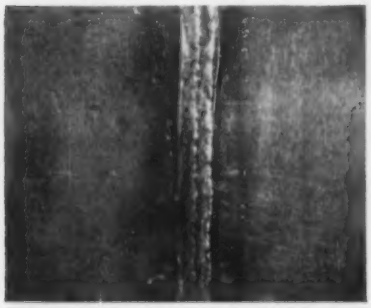
2. Using 5/32-in, "141" Nickel Electrode, weldor overlays copper with overlapping beads. The two layer overlay is run well over the edges of the bevel.

3. After 3/16-in nickel overlay has been applied to pre-heated copper, 40° bevel is restored. Straightedge is used to assure bevel is even and true.

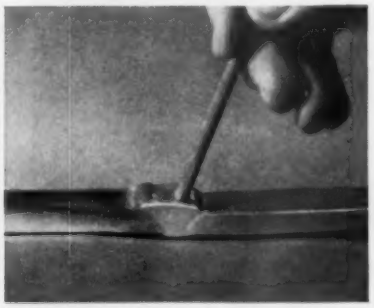
4. Type 347 stainless steel, left, is positioned with copper to allow root spacing of ⅛-in. Both ends of the copper to stainless joint are then tacked.

5. Root pass is run in, followed by beads that alternate between sides and middle of root. Current is now 200 amps. "141" Electrode is 3/16-in diameter.

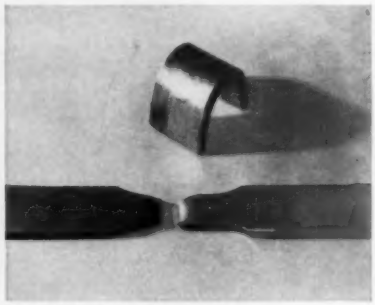
6. Chipping out slag and wirebrushing is important to quality of final weld properties. Weld should not extend beyond the nickel overlay on copper.



7. Closeup of the final weld shows even contour, good fusion and good penetration. Copper is on the left, type 347 stainless steel is on the right.



8. Cross section of weld, after etching and macro examination, shows no porosity, cracking, fissures, slag entrapment. Weld is then tested further.



9. Longitudinal bend test proved no failure. Copper to stainless weld is strong, ductile, sound. Short gauge tensile test broke in copper at 33,200 psi.

How to weld Copper to Stainless Steel

Of all the so-called "problem joints," welding copper to stainless steel is considered one of the most difficult. Many weldors say it's impossible. But it can be done . . . and done well with Inco's "141"* Nickel Electrodes. Or with Inco's "61"* Filler Wire if you're set up for MIG or TIG welding.

Above, we have outlined a recommended procedure for welding copper to stainless steel. Your local distributor of Inco Welding Products, listed under "Nickel" in the classified, can give you more information, as well as the sizes and prices of "141" Nickel Electrodes and "61" Nickel Filler Wire.

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Creatures of Habit

Today, in spite of some 40 years of effort, we still face the task of selling the advantages of welded products in applications where the use of welding would be a definite improvement over other fabricating means.

Why? Largely, I believe, because we are creatures of habit. Our constant challenge is to be different.

Suppose, for a moment, that the methods of joining metal had been reversed in the sequence of their historical development. Suppose welding had preceded riveting, and that subsequently riveting had been invented. The inventors would have been in the position of telling us that joints should not be made by fusing metal together, but that the more efficient way would be to lap the joints, or use extra lapping plates on each side, then punch the sound metal full of holes and fill the holes with rivets. You can imagine the commercial effect that the proponents of riveting would have made under these conditions.

The same situation would have prevailed if weldments had been used for machinery construction before castings. Who could have sold us a piece of equipment by telling us that it was weaker, less rigid and more expensive?

In welding, if we are to overcome this strong force of habit, we must accept the challenge to do things differently. We must question ourselves critically. Are we overdesigning? Are we overwelding? Are we using the best available procedures? Are we specifying more inspection than is required? Are we submitting welding to tests beyond the limits of practicality? We must be sure that answers are not based on standards that have been obsoleted by technical progress. In many instances, our answers today are unnecessarily increasing the cost of welding.

Welding has made great progress. Its achievements, however, have stimulated competition into activity. If we are to continue our progress, we must sharpen our competitive advantages at every opportunity. We must investigate new approaches to our problems until we find the best solutions. We must be realistic, forfeiting any old ideas we may cherish as creatures of habit.

C. G. Herbruck

ASSISTANT TO THE SECRETARY
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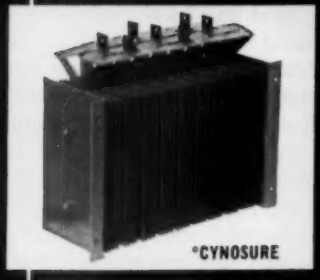

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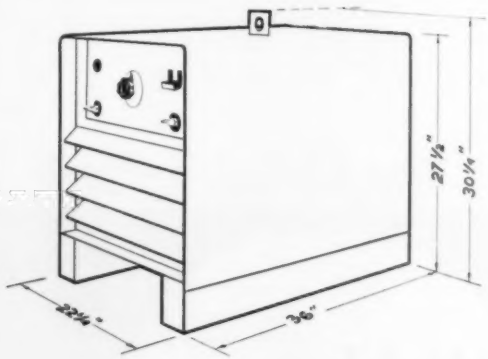

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*CYNOSURE: Anything to which attention is strongly turned: a center of attraction.

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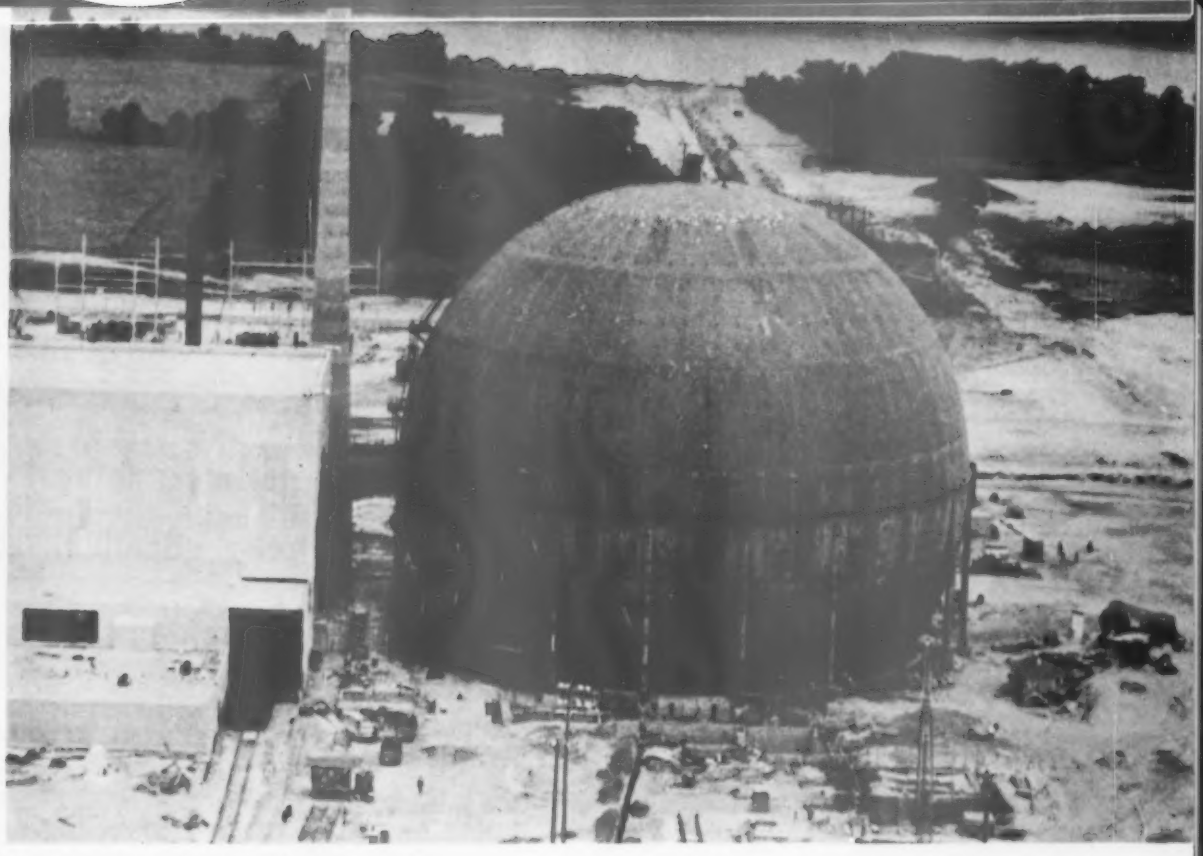

Fig. 1—Partially completed Dresden Power Station

Paper describes the testing, planning and laboratory work performed in order to meet the various code requirements for the

Welding of **Containment Sphere** for Dresden Nuclear Power Station

BY PERRY C. ARNOLD

Introduction

Several large commercial nuclear power stations are presently being constructed in the United States. One of the largest of these is the 180,000-kw boiling-water reactor-type station near Chicago, Ill. As an added safety factor, the nuclear reactor and other equipment are enclosed in a containment vessel[1] of spherical shape. The main shell plates of this spherical structure are of 1.40 in. maximum thickness with the reinforcing plates and forgings for some of the openings running from 3 to 6 in. in thickness.

The ASME Code Case 1226-3 has ruled that containment vessels fall under the category of those containing lethal substances but that they still may be built without stress relieving provided that the following requirements are met:

1. Plates and forgings used in the vessel wall along with the weld metal and heat-affected zones must meet the Charpy-keyhole impact values of 15 ft-lb at −50° F.
2. All doors, nozzles and opening frames must be preassembled into shell plates and stress relieved as complete assemblies for butt welding into the shell.
3. When shell plates of thickness over $1^1/_4$ in. and up to $1^1/_2$ in. of P-1 material are used, a preheat of 200° F must be used during welding.
4. All longitudinal and circumferential joints shall be of the double-butt welded type and shall be

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Paper presented at the AWS 40th Annual Meeting held in Chicago, Ill., April 6–10, 1959.

Fig. 2—Preassembly of spherical shell plates

Fig. 4—Automatic welding using double-directional tilt table

Fig. 3—Twin-arc automatic welding machine in operation

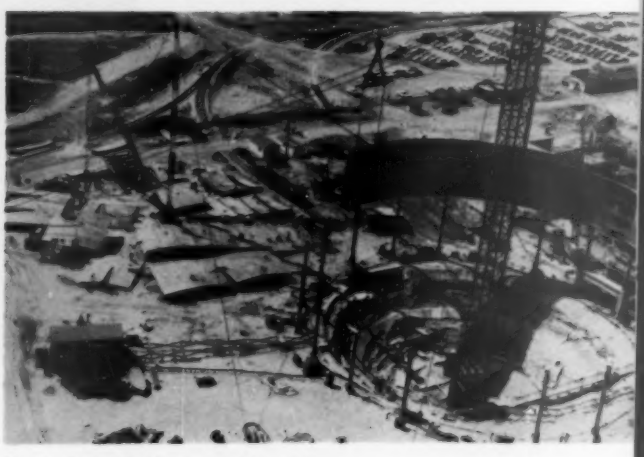

Fig. 5—General view of erection site

fully radiographed. All welds on doors, nozzles and openings and all welds that cannot be radiographed shall be examined by the magnetic-particle or fluid-penetrant method.

Much of the story of this paper concerns the testing, planning and laboratory work that were required in order to meet the above and other code requirements.

Description of Structure

Figure 1 is a view of the partially completed Dresden Nuclear Power Station. The spherical containment vessel is 190 ft in diam and was designed for an internal pressure of 29.5 psi. The shell plates range in thickness from 1.25 to 1.40 in. They are of A201 Grade B firebox material meeting the A300 specification which requires a Charpy-keyhole notch toughness value of 15 ft-lb at −50° F. This sphere is self-supporting, free of internals and is capable of resisting a minimum external pressure of 1 psig together with the effect of all dead loads. The spherical structure was designed to meet the ASME Code specifications including Section II for materials, Section VIII Unfired Pressure Vessels, Section IX Welding Qualifications and all Addenda and Code Cases.

Erection and Welding Requirements

The erection method and schedule required the assembly of large sections on the ground. Figure 2 is a view of the ground assembly yard. Here three or more shell plates are assembled into one unit and the joints automatically welded and radiographed. Paragraph UG-84 of Section VIII of the ASME Code requires that not only must the plate material be tested for notch toughness with the Charpy-keyhole method, but also the adjoining weld metal and heat-affected zones. Although submerged-arc welds normally have excellent ductility and toughness, there is a limiting thickness of weld metal, when using a single-head, single-pass system, above which consistent high impact results cannot be obtained. This limit is very close to the $1^1/_4$-in. plate thickness automatically welded with a single pass each side. Since most of the plate material in this structure was over $1^1/_4$ in. in thickness, either the multipass system of automatic welding had to be used or another procedure had to be found.

Many large test plates were automatically welded together in the laboratory using various combinations of electrodes and submerged melt. No combinations could be found that would give consistent weld-metal keyhole-Charpy values of 15 ft-lb at −50° F when welding 1.40-in. thickness material with a single head and a single pass from each side. The impact values varied considerably with approximately 50% falling below 15 ft-lb and the other 50% at 15 ft-lb or just slightly higher. A solution to this single-pass welding from each side was found by using the twin-arc method of welding.

Figure 3 shows the twin-arc welding machine which was used to weld automatically all of the ground-assembly joints for the sphere. Two $^5/_{32}$-in.

diam electrodes are fed into the weld puddle under a common blanket of melt and slag. Each electrode has its own separate power source supplied by a number of rectifier-type welding machines in parallel. The electrodes are spaced from two to four inches apart. This twin-arc method of welding provided enough additional grain refinement in the weld metal so that consistently good impact values were secured. For the first side welded, the leading electrode uses low amperage and the trail, high. For the second side, the leading electrode uses high amperage and the trail, low.

Figure 4 is another view of the twin-arc machine in operation along with the double-directional tilting table which keeps the portion of the joint being welded in a flat position. The electrode which was found to give weld metal with the highest impact properties contained approximately 0.08 carbon, 0.43 manganese and 0.03 silicon. This electrode combined with a melt high in manganese gave the best results. The tensile and elongation properties of the weld metal were also excellent. No cracking troubles were experienced. Some porosity, lack of fusion and slag entrapment were experienced until

Fig. 6—Welding of sphere joints in vertical position

the operator became thoroughly familiar with the operation of the twin unit. The footage of joint repaired as required by the radiographic inspection was less than 2%. The time for welding a joint with the twin-arc method was considerably less than the time required to weld a section using the multipass method.

Figure 5 shows a general view of the construction site, including the preassembly yard and the erection of the equator course of the sphere. After the preassemblies were completed on the ground, including radiography of the joints, they were hoisted into the air and assembled into the sphere proper. All joints between the large preassembly sections were then manually welded together and radiographed. Again, the selection of the satisfactory manual electrode and welding procedure had to be carefully evaluated in order to make sure that the impact requirements were adequately met. Procedure tests made in accordance with Section IX of the ASME Code demonstrated that most electrodes would give weld metal of adequate strength and ductility but few would pass the impact requirements. This was especially true when welds were made in the vertical position as shown in Fig. 6.

The E6010 electrode was not considered for possible use because of its inherently poor radiographic quality. The low-hydrogen electrodes E7016 and E7018 were selected for testing and only one was found which would give weld metal in the vertical position with adequate impact properties. Further testing of the weld metal from this electrode proved it to have very poor radiographic qualities. Therefore, it was discarded on that account. The electrode companies were advised of these results and finally after some sixty new formulas were tried, one company produced an E7018 electrode that gave both high impact results and radiographically sound weld metal. This electrode produced weld metal of a low-carbon, high-manganese content with a careful balance of the manganese-to-silicon ratio. The cartons of electrode were hermetically sealed and marked "Special." The use of the special marking was done to insure that no standard E7018 electrode would be used on the job.

As stated before, Code Case 1226-3 requires that a 200° F preheat be used when welding joints of containment vessels when the thickness of material exceeds 1.25 in. Since the majority of plates in the structure were thicker than 1.25 in., preheat was used throughout. Propane burners approximately 10 ft long were used and the joints preheated to a minimum of 200° F before welding. The cost of providing a continuous and even preheat is tremendous. Whether this cost is justified when using low-hydrogen electrodes is questionable.[2] It is recognized today that accelerated cooling of mild-steel plates improves their impact properties. Might this not also be true of the weld metal?

To evaluate this question and also to see what effect welding with low-hydrogen electrodes has on non-preheated A300 steel, the test described hereafter was conducted.

Description of Test

Two pieces of scrap plate from the Dresden sphere material were assembled for welding as shown in Fig. 7. These plates were about 6 in. wide, 18 in. long and $1^{3}/_{8}$ in. thick. Heavy strong backs were welded

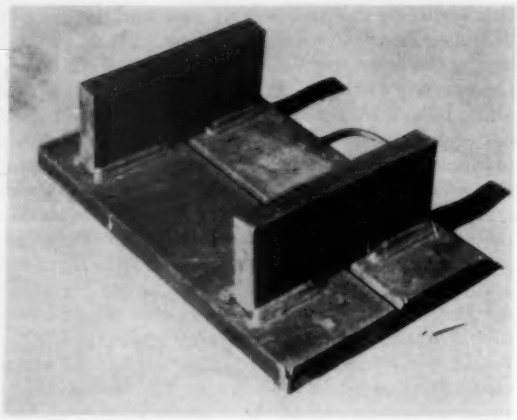

Fig. 7—Assembly of test plate

Fig. 8—Ice bath and temperature-checking equipment

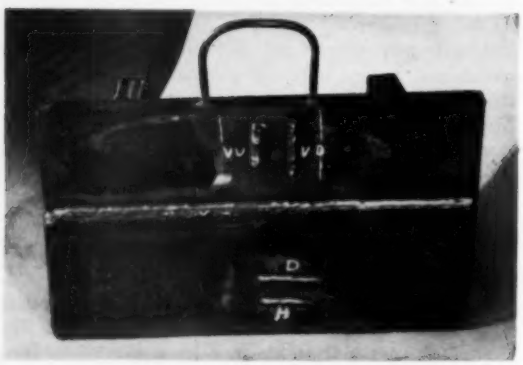

Fig. 9—Test plate after completion

across the joint and left in place until the butt weld was completed. These heavy strong backs provided high angular and lateral restraint to the butt weld. The weld was made in the horizontal position, that is, the axis of the plates was vertical and the axis of the weld horizontal. This position was chosen so as to secure the most rapid quench of the weld metal and the heat-affected zone. The bottom plate had a square edge and the upper plate was given a double 45-deg bevel with a $^{1}/_{8}$-in. land. This was done in order to secure a heat-affected zone in a straight section which would facilitate the taking of Charpy impact specimens from this zone.

The test plate after assembly was placed in a bath of salt, ice and dry ice and left there until it reached a temperature of 26° F. It was then removed from the bath, the joint dried with a blast of air and the first pass deposited. Figure 8 shows the cooling bath and the temperature checking instrument. The plate was carefully checked to see that the temperature was always 30° F or lower before welding was started. Following each pass of weld metal, the bead was cleaned and the plate returned to the ice bath. The first pass on each side was deposited with $^{5}/_{32}$-in. diam E7018 electrodes. The rest of the passes were made with $^{3}/_{16}$-in. diam. E7018 electrodes except for the last stringer pass at the top of the joint which again was made with the $^{5}/_{32}$-in. diam electrodes.

Figure 9 shows the test plate after it was completely welded. Note that four single-pass beads were run on the surface of the plate above and below the butt weld. These beads were made in the flat down, horizontal, vertical-up and vertical-down positions. With the test plate at 30° F, these single-pass welds undoubtedly produced the fastest quench rate obtainable.

Results of Test

After the weldment was completed, the test plate was X-rayed and found to be sound and free of cracks. Following the X-ray examination, the following test specimens were removed from the weldment:

- 4—guided-bend specimens
- 2—free-bend specimens
- 1—longitudinal-bend specimen
- 1—longitudinal macro-etch specimen
- 1—cross section for hardness survey
- 1—longitudinal and 1 cross section of bead on plate, flat down
- 1—longitudinal and 1 cross section of bead on plate, horizontal
- 1—longitudinal and 1 cross section of bead on plate, vertical up
- 1—longitudinal and 1 cross section of bead on plate, vertical down
- 10—Charpy-keyhole impact specimens from the weld metal
- 10—Charpy-keyhole impact specimens from the heat-affected zone.

Fig. 10—Guided side-bend specimens

Fig. 11—Free-bend specimens

Fig. 12—Guided longitudinal bend and macro-etched specimens

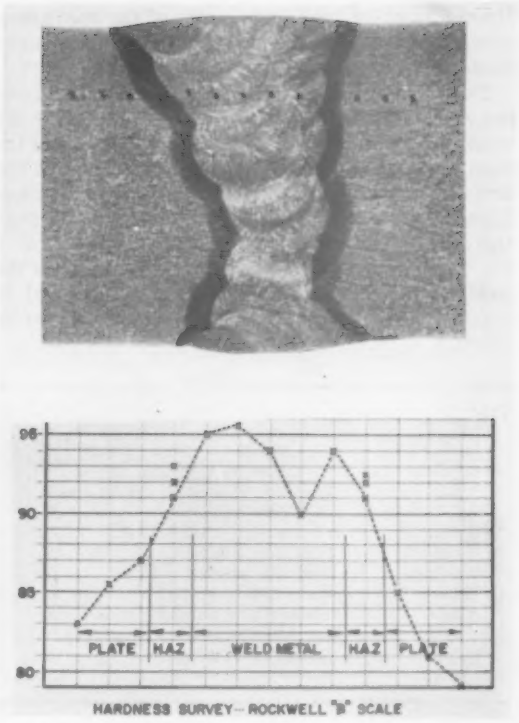

Fig. 13—Transverse section of weld and hardness survey

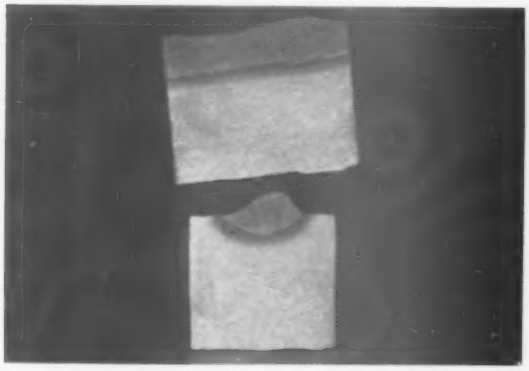

Fig. 14—Macro-photograph of longitudinal and cross sections of horizontal bead-on-plate weld

Figure 10 shows the results of the guided side-bend specimens. All made the 180-deg bend without difficulty. No cracks opened up either in the weld metal or the heat-affected zone.

Figure 11 shows the two free-bend specimens. The measured elongation across the weld was 41 to 44%. Again no cracking occurred during the severe bending.

Figure 12 shows a guided longitudinal bend and a longitudinal macro-etch specimen. Any micro-cracks present in the weld metal or the heat-affected zone would certainly show up in both of these specimens. None could be found.

Figure 13 is a cross section of the horizontal weld. Note the soundness of the weld metal and the absence of any cracking in the heat-affected zone. A hardness traverse was made across this section and the result is as shown. Note that the hardest area is in the weld metal, not in the heat-affected zone.

Figures 14 and 15 are macro-photographs of the longitudinal and cross sections of the bead-on-plate welds for the horizontal and vertical-down positions.

No cracks could be found in any of the specimens. A microscopic examination of the specimens failed to show any microcracks.

Ten Charpy-keyhole specimens were taken from the weld metal. The specimens were taken from the weld with their axes at right angles to the axis of the weld and the axis of the hole at right angles to the surface of the plate. Five specimens were taken from one side of the double-butt weld and five from the other side. The specimens were taken from a location in the weld half way from the center of the weld to the plate surface. These were cooled to −50° F and broken, giving the results shown in Table 1.

Table 1

MK		Ft-lb (at −50° F)
A-0	First side welded	28
A-1	First side welded	31
A-2	First side welded	31
A-3	First side welded	27
A-4	First side welded	28
A-5	Second side welded	24
A-6	Second side welded	29
A-7	Second side welded	28
A-8	Second side welded	32
A-9	Second side welded	28

Ten additional Charpy-keyhole specimens were taken from the heat-affected zone in the bottom plate. The specimens were taken from the heat-affected zone with their axes at right angles to the axis of the weld and the axis of the hole at right angles to the surface of the plate. It is quite difficult to locate the notch exactly in the area desired and, as a result, only four of the specimens showed the notch to be entirely within the heat-affected zone, while the other six were partially in the heat-affected zone and partially in the weld metal. The results are shown in Table 2.

Table 2

MK		Ft-lb (at −50° F)
B-5	100% heat-affected zone	23
B-7	100% heat-affected zone	21
B-8	100% heat-affected zone	21
B-9	100% heat-affected zone	17
B-0	Part heat-affected zone, part weld	22
B-1	Part heat-affected zone, part weld	23
B-2	Part heat-affected zone, part weld	26
B-3	Part heat-affected zone, part weld	24
B-4	Part heat-affected zone, part weld	23
B-6	Part heat-affected zone, part weld	22

Conclusions from Test

Preheat apparently contributes nothing to the notch toughness of the weld metal or heat-affected zone when welding A201 Grade B to A300 Specifications with *low-hydrogen electrodes*.

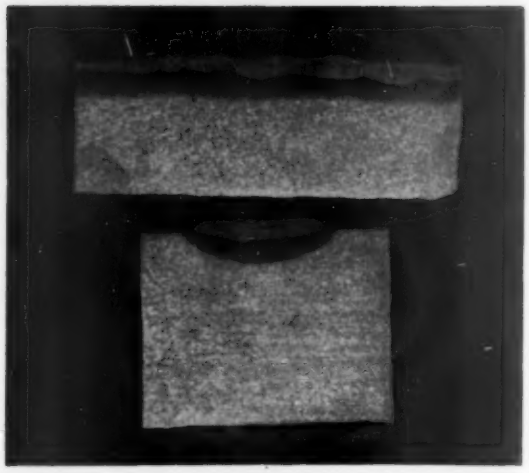

Fig. 15—Macro-photograph of longitudinal and cross sections of vertical-down bead-on-plate weld

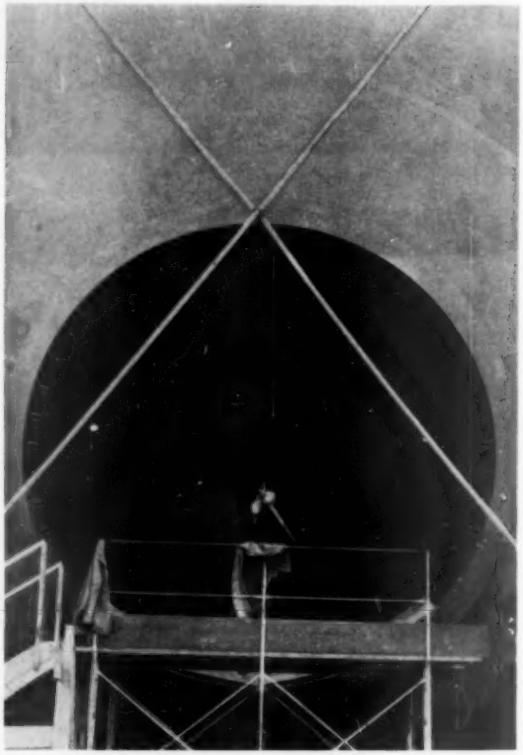

Fig. 16—View of 16-ft ID bolted opening in spherical shell

No micro- or macrocracks could be found in any of the test welds made on these heavy plates at 30° F.

From these tests it appears that the code requirement of using preheat at 200° F when welding on material over $1^1/_4$ in. in thickness was based on the

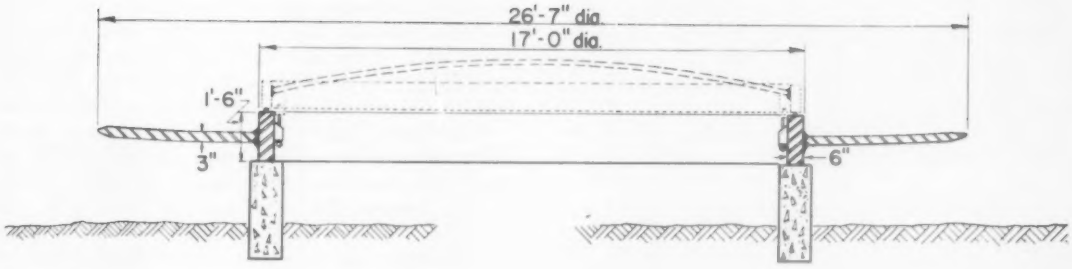

Fig. 17—Sectional view of 16-ft diam opening

welds being made with electrodes other than the low-hydrogen types.

Also from these tests it would appear that good, sound, crack-free welds can be made on this material without the use of preheat to as low a steel temperature as 30° F, and quite possibly lower.

Field Stress-relieving Requirement

In the design of the containment sphere it was found necessary to provide a 16-ft ID opening. Figure 16 shows this opening installed in the shell of the vessel. Since this fitting was too large for shop assembly and stress relieving, it had to be field assembled, welded, radiographed and finally field stress relieved in accordance with ASME Code Case 1226-3.

Figure 17 is a sectional view of the 16-ft diam opening. For assembly and stress-relieving purposes, the ring or neck of the opening was set on a concrete ring wall and then the reinforcing or insert plates fitted to the ring. The assembly consists of 16 ft-0 in. ID x 17 ft-0 in. OD A350-LF-1 seamless forged ring 1 ft-6 in. long, welded to a 3 in. thick by 26 ft-7 in. OD dished insert plate of A201 B material to A300 specifications. The splices in the insert plate were welded first and then the plate was welded to the ring. The insert plate was preheated to 300 to 400° F while the ring was kept at approximately 200° F. Once welding was started it was continued on a three-shift basis until completed. The splices in the insert plate were 100% radiographed and the weld of the insert plate to the forging was magnetic-particle inspected several times during welding and after the assembly reached ambient temperature. No cracking troubles were experienced.

Following the successful welding of the assembly, the bolted cover was set in place and securely locked to the forging ring. A stress-relieving house or furnace was built around the assembly and the completed structure brought up to 1100° F and held for 6 hr. Propane burners were used as a heat source. Many thermocouples were attached to the assembly and a record was made of the postheat treatment on a recording pyrometer. The temperature of the assembly had to be raised quite slowly in order to keep temperature gradients low between the heavy and thin materials. The complete cycle for the postheat treatment took slightly over 36 hr. After the

Fig. 18—X-raying ground-assembled sections

assembly returned to ambient temperature, the splices in the insert plate were again re-radiographed and the weld joining the insert plate to the heavy ring was thoroughly inspected by the magnetic-particle process. No cracks were found.

Inspection and Tests

Throughout the fabrication and erection of the containment vessel, insurance inspectors were employed to follow the work both in the shop and in the field. In addition, special supervisors were assigned to the work in the shop, and two welding supervisors were assigned on a full-time basis to assist with quality control in the field. All of the butt-welded main joints in the vessel wall were 100% radiographed and less than 1.4% of the total joint footage (15,000 ft) in the shell had to be repaired as shown by the radiographs. Figure 18 shows one of the X-ray machines used on the job. Figure 19 shows a portable dark room that was used for processing the films.

Weldments that could not be radiographed were magnetic-particle inspected at least twice, once before the test and once after the test. Many of these weldments were also magnetic-particle inspected during welding prior to stress relieving and also directly after stress relieving. Also, all of the manually welded butt joints were magnetic-particle inspected following the carbon arc-compressed air gouging operation and prior to the welding of the back side. This was done as double insurance against leaving any first-pass cracks in the joints.

Fig. 19—Portable dark room for processing X-ray film

After the containment vessel was erected, welded and radiographed, a pneumatic test was made. First the vessel was pressured to 5 psig and all the welds and seals were given a soap-suds test. Having passed this test, the vessel was pressured to 37 psig which is $1^1/_4$ times the working pressure of 29.5 psig. The pressure was then lowered to 29.5 psig and another soap-suds test was given to all the welds and seals. Figure 20 shows the soap-suds test being applied to the main joints of the vessel wall. Following this test and with the vessel at 29.5 psig, a leakage-rate test was conducted over approximately a 30-hr period. After all these tightness tests were successfully completed, the pressure was released and again all the openings, nozzles and other fittings were reinspected by the magnetic-particle process. This was done to make sure that no cracks occurred during the overload test.

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Fig. 20—Soap-suds testing the welded joints

A typical rocket test being conducted. The new track will handle sleds weighing up to 100,000 lb at the critical velocity of about 2900 fps

Oxyacetylene Pressure Welding

of High-Speed Rocket Test Track

at Edwards Air Force Base contributes to increased capabilities of facility and helps to make possible the testing of complete weapons systems or full-scale components

BY E. S. McKITTRICK AND W. E. DONALDS

SYNOPSIS. A facility construction program is currently under way to install a 20,000-ft rocket test track at the Air Force Flight Test Center, Edwards Air Force Base, California. This construction will extend the test speed capabilities to speeds as high as Mach 4 or about 4 times the speed of sound, in specific instances, and will facilitate the testing of complete weapons systems or full scale components.

When completed, the track will consist of 20,000 ft of 171-lb special rolled crane rail. The rail will be continuous welded by the oxyacetylene pressure-welding process, and will be mounted on continuous steel-reinforced concrete beams.

This paper presents a general discussion of track facility developments at the Air Force Flight Test Center at Edwards Air Force Base, and discusses more specifically the procedures used in oxyacetylene pressure welding and the techniques used in laying 10,000 ft of the new high-speed test track. Work has just been completed on replacing the original 10,000-ft track with the new oxyacetylene pressure-welded rail. The old track consisted of 115-lb rail utilizing open-joint construction.

The nature of this project demanded exacting accuracy and precision throughout the various phases of welded-rail production and laying of finished rail. This paper deals with the precision handling of each of the following five production phases: (1) rail-end preparation, in which the rails were cropped by automatic saw to insure a perfect fit during welding; (2) pressure welding at approximately 2550° F with a specially designed oxyacetylene heating head; (3) normalizing to relieve stresses within the rails; (4) grinding the head, web and base of the welded joint to original rail dimensions; and (5) weld testing with the magnetic-particle inspection process to assure top-quality welds.

Specifications for the welded track required extremely close tolerances. The rail alignment, for example, is ±0.036 of an inch for the entire 20,000-ft length of the track. The second part of this paper deals with the problems associated with maintaining these close tolerances and placing the track in operation. This includes anchoring the track every 3 ft with steel bolts, and utilizing hydraulic devices to tension the track.

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Introduction

While captive-flight testing by means of track media is not a new development, the use of continuous welded rail is a relatively new departure in rocket test-track construction. Preliminary investigation of tracks as a testing medium took place in 1944, and led to the construction of a 2000-ft test track at the Air Force Flight Test Center at Edwards.

The operational success and high speed obtained on this track led to the installation of the free-air test facility consisting of 10,000 ft of precision aligned standard-gage high-speed track. This track was built for the purpose of investigating aerodynamic parameters in the transonic range.

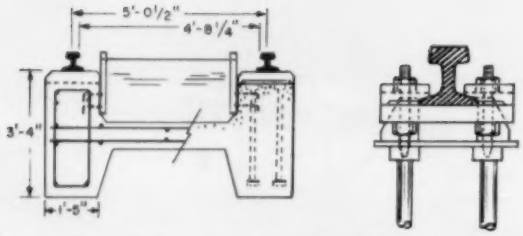

Fig. 1—Schematic cross section of 20,000-ft track showing water brake (left) and sleeper detail (right)

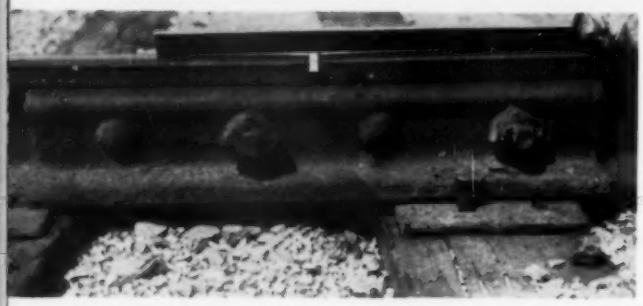

Fig. 2—Battered rail ends, such as those shown here, have been eliminated with the use of continuous welded rail

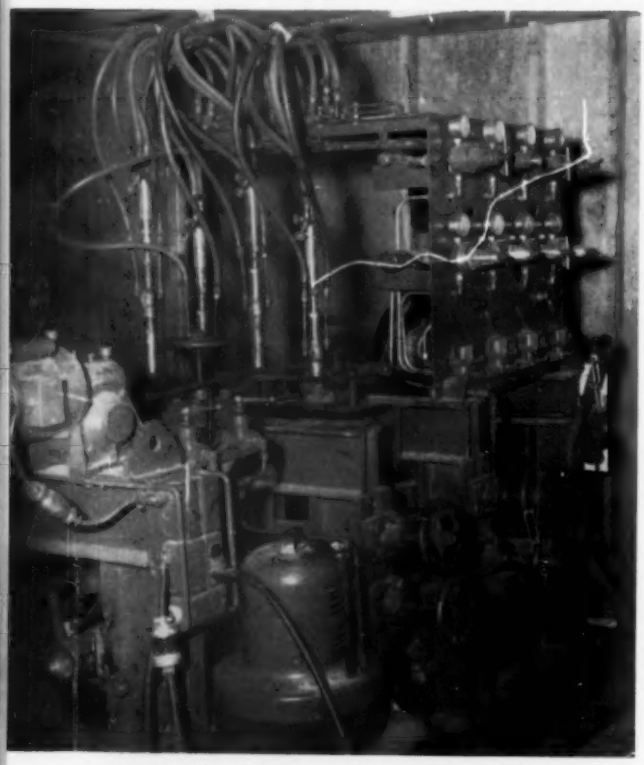

Fig. 3—This standard oxyacetylene pressure-welding machine was used for this project. No changes in equipment were necessary in order to weld 171-lb rail

Constructed of 115-lb standard railway rails, this track was laid on continuous reinforced-concrete beams. It was not continuous welded, and the rails were not joined at the ends. To insure lateral stability and constancy of gage, the two beams were tied together at frequent intervals by reinforced-concrete struts. The rails were attached to the foundation beams in such a manner that precision alignment of the rails could be obtained.

Although operations on this track proved highly successful, the speed was limited by the combination of track length, recovery capability and allowable acceleration. In addition, the severe vibration stresses caused by the high speeds and high thrust and drag loads, resulted in frequent and costly track realignment and maintenance. Because of these factors, it was decided to replace the conventional rail with oxyacetylene pressure-welded rail.

The rail selected for the new track project was 171-lb crane rail which has a cross section of 18 sq in. Details of rail and track are shown in Fig. 1.

Oxyacetylene Pressure Welding

The oxyacetylene pressure-welding process is a method for producing continuous welded rail, and thereby eliminating the need for conventional bolted joints. First developed more than 20 years ago, it is now used by 40 major railroads, and has found—and will continue to find—considerable use in rocket test-track construction.

No matter what type of rail is used, the rail joint in conventionally laid rail is the weakest point. In railroad use, for example, when heavily loaded cars pass over the rail joints, the severe pounding action damages ties, batters the rail ends, as is clearly evident in Fig. 2, and shifts the ballast in the surrounding area. The force is also transmitted to rolling stock, causing wear on equipment, damage to freight—and, of course, discomfort to passengers. Since there are usually 270 joints in each mile of track, this pounding has considerable ill effects.

The same is true of conventionally laid rail on rocket test tracks. Only here, such pounding is greatly magnified due to the critical velocities, which in some instances exceed Mach 2.

Aside from its ability to withstand the extreme stresses imparted by the test vehicle at high speeds, pressure-welded track offers these other advantages for rocket test tracks.

1. Reduction in Maintenance Costs. Maintenance of rail ends and joints is virtually eliminated. Since this is the area where most maintenance is required, costs are considerably reduced.

2. Longer Track Life. Rails do not have to be replaced because of battered ends, and track will maintain the precision alignment necessary for high-speed testing.

3. Increased Operational Effectiveness. By eliminating misalignments, greater accuracy is assured in the test data obtained.

4. Safer Operations. There is no danger of accidents from loose, out of line or worn rail joints.

Fig. 4—From this table, rails are pushed into the first station, where rail cropping is done. All stations in the production line are located about a rail length apart

Fig. 5—First step in the production of continuous welded rail involves cropping the rails. This is done by butting the ends of the rail together and making a single cut between them with a rail saw

Welding Procedures

The successive operations in oxyacetylene pressure welding for this project were performed in a continuous production line. A standard oxyacetylene pressure-welding machine (Fig. 3) was used. With the exception of utilizing greater pressure during welding, no major changes were made in order to weld 171-lb rail. Stations were located approximately a rail length apart to facilitate handling. The following is a step-by-step description of the procedures used.

Rail-end Preparation

As shown in Fig. 4, the rails are moved by hand from a loading table onto rollers where they are pushed into the first of three shelters. To produce a sound weld, rail ends must be matched to fit together snugly end to end. This was done by butting the ends of the two rails together and making a single cut between them with a rail saw (Fig. 5). The rails were then inspected for flaws. If a flaw was detected, another cut was made.

Welding

Following rail-end preparation, the clean rails were moved to Station No. 2, filed to remove burrs, cleaned with a solvent and then centered in the welding machine and forced together by hydraulic clamping devices under a pressure of about 53,000 lb. This pressure was applied continuously during welding. A special welding head, consisting of four blocks of tips, directed a series of oxyacetylene flames around the rail ends, oscillating back and forth over the weld area. View of welding head in operation is shown in Fig. 6. No filler rod was used. At about 2250° F the rail became plastic. The two rails moved together about $^{15}/_{16}$ in., and fused under pressure to form the pressure-welded joint. Tolerance in alignment of rails at the time of welding was checked by straight edge. The sides and top were aligned within 0.025 in. of each other.

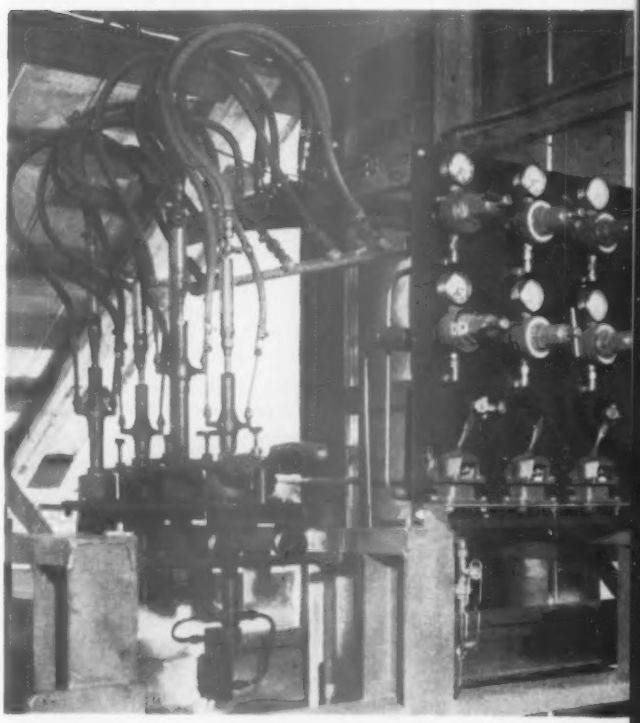

Fig. 6—View of oxyacetylene pressure welding in operation. While welding is taking place, the rails are forced together under a pressure of about 53,000 lb

Fig. 7—The method of removing "upset" metal from the weld is demonstrated here. Operator is using a cutting torch equipped with a gouging nozzle

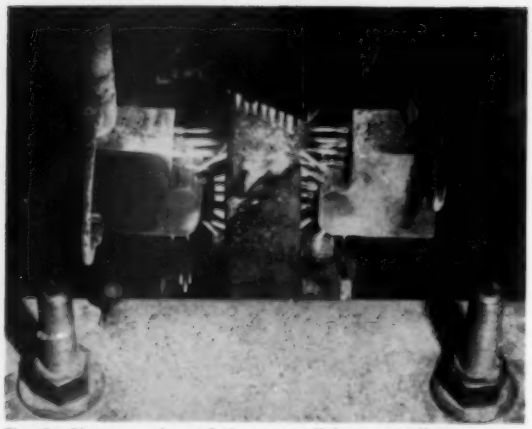

Fig. 8—Close-up view of the normalizing operation. Top heating head is angled to provide a more gradual transition of the normalized zone

The weld was then tested with ordinary straight edge to see if it met minimum requirements as to reinforcement and alignment.

Over all, a total of 1056 oxyacetylene pressure welds was made on the project. Average time for each completed weld was 7 min. It is interesting to note that the average time per completed weld in 115-lb rail is 5 min. A total of 136,800 cu ft of oxygen and 141,000 cu ft of acetylene were used to make the 1056 welds. Oxygen and acetylene were supplied from manifolded cylinders located on a platform adjacent to the welding equipment.

It should be pointed out that, usually, on rail-welding projects of a more permanent nature, such as those undertaken by the railroads, bulk oxygen and generated acetylene is used to effect substantial savings in cost over the use of manifolded cylinders.

Upset Trimming

The hydraulic pressure applied to the rails during welding forced the rails together and caused the metal around the weld to "upset," forming a bulge around the joint. The major portion of the bulge was removed with an oxyacetylene torch employing either a washing or gouging nozzle. Method of removing "upset" is shown in Fig. 7.

Normalizing

To relieve any internal stresses set up in the metal by welding, and to improve weld quality, the weld area was heated to about 1500° F by an oscillating heating head similar to the welding head. The flames were directed across the top of the head or "ball" of the rail at an angle of 45 deg (Fig. 8). Thus, the dividing line between the normalized and unnormalized zones of the head runs at a 45-deg angle across the rail, providing a gradual transition between the two zones.

The normalized weld was allowed to cool naturally in the atmosphere. Experience has shown that a nor-

Fig. 9—Rough grinding of the weld was done following normalizing. Shown below is the special grinding machine designed for this project

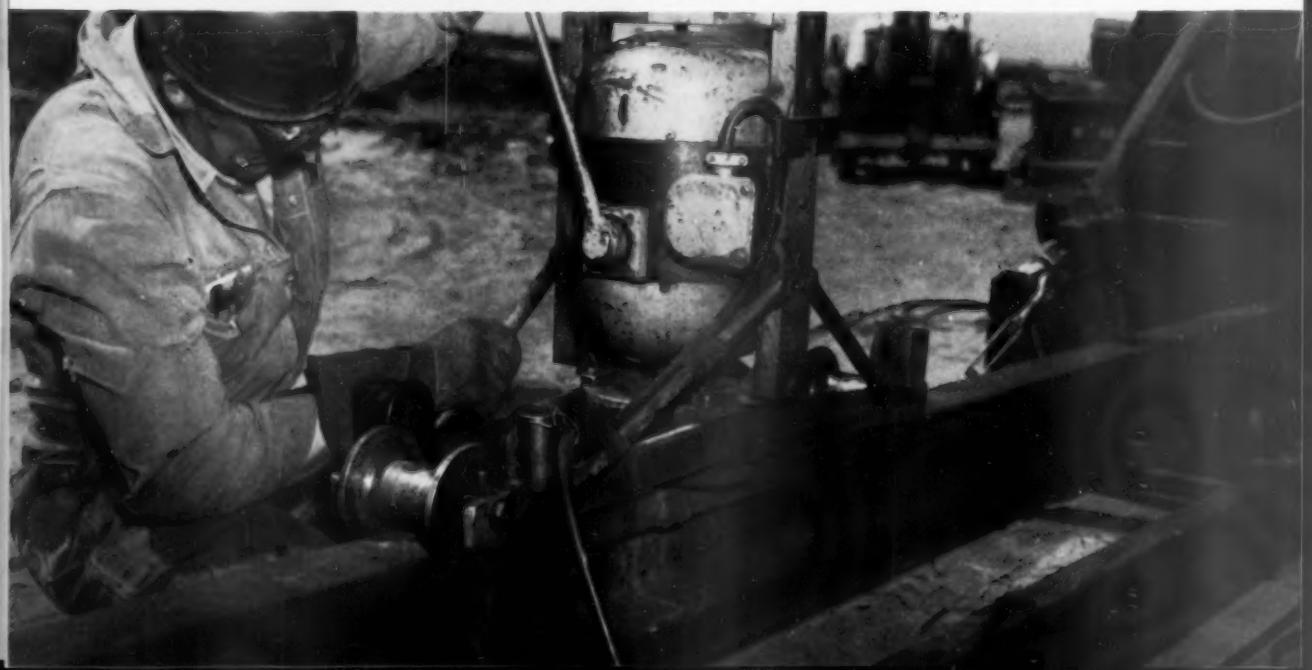

Fig. 10—Close-up of the magnetic-particle inspection method used to test the weld for defects

Fig. 11—This view of the concrete beam shows the studs used for adjusting and positioning the sleeper-bed plates

malized weld is metallurgically superior to one that has not been normalized, and much less likely to fail under repeated strain.

In addition to removing the stresses, the normalizing operation also permitted minor alignment adjustments to be made. In about 50% of the welds it was found that displacements greater than the allowable tolerance had taken place. This was in the order of 0.025 to 0.040 in. Such misalignments would not be serious, or even noticed for railroad rails, but would be detrimental for a precision track of this type. To correct this, a special jacking device was built adjacent to the normalizer and was used to realign the rails at the joint while they were in a plastic condition. This was an innovation for this particular job and was very successful. The normalizing and straightening equipment was designed to move longitudinally so that it was unnecessary to move the rail for this operation.

Weld Finishing

All of the rough grinding, as shown in Fig. 9, was done in normal sequence adjacent to the welding equipment. Some fine grinding, by means of abrasive belts, was done before pulling the rail into position. However, finish grinding was completed after the rails were anchored in position. Grinding specifications called for no portion of the weld to be above the adjacent portion of the rail and no point to be more than 0.005 in. below. This applied to all portions of the top flange or "ball" and for distance half way down the weld.

Inspection

All welds were inspected by the magnetic-particle inspection method to check for possible defects (Fig. 10). If rails do not pass the magnetic-particle test, they are rejected and have to be welded again. However, in this project the entire 1056 welds were made without one single reject.

Rail-laying Operations

At the high speeds utilized in the track test program, even a slight deviation in track alignment could create excessive lateral or vertical forces that would wreck the flight test vehicle as it raced down the rails. For this reason, extremely close tolerances were established and maintained for construction of the foundation and final alignment of the welded rail. Specifications called for the final alignment to be ± 0.036 in.

In order to obtain an accurate base line from which to align the rails, the U.S. Geodetic Survey and the Corps of Engineers established bench marks and alignment points on brass monuments attached to the concrete every 51 ft and adjacent to the master rail.

The rail was supported in position by a steel-reinforced concrete H-beam which extended approximately 2 ft below the ground level. Figure 11 shows a close-up of the concrete beam and detail, including the studs used for adjusting and positioning (as to height and vertical alignment) of the sleeper-bed plates.

Temporary rollers were placed along the track bed

to facilitate stringing the rail. The rollers also served to lift the rail slightly off the sleeper-bed plates in order to obtain uniform axial loading along the entire rail length.

For alignment, special optical instruments were used to align the "master" rail and mechanical gages with dial indicators were used to set the companion rail (Fig. 12). One set of instruments was used for vertical alignment and one for horizontal. Precise levels were used for rotation and leveling from the master to the companion rail. All instruments could be read to 0.001 in. and were accurate to 0.003 in. Optical alignment was performed at night when atmospheric conditions were best.

It was required that the track rails be installed in such a manner that a final zero-stress temperature of 115° F was achieved for the rails. To produce this result, the hydraulic jacks and tensioning nuts shown in Fig. 13 were used to hold the rail at proper tension until clamped in position.

A known temperature of 10° F occurred during November 1958. This resulted in a 105-deg temperature change and would be approximately 21,000 psi in tension or a total of 345,000 lb per rail. A careful inspection made when the track was below 20° F revealed no indication of failure.

To provide a vibration-dampening medium, the spaces between the top of the concrete beams and bottom flange of the rails between sleepers was filled with asphalt. Close-up of this area is shown in Fig. 14.

Track Capabilities

The new track will extend the test-speed capabilities, and will make possible the testing of complete weapons systems or full-scale components. It will be used for full-scale and model flutter tests, and also to assess the performance of subsonic, transonic and supersonic speeds of parachute-type recovery systems, seat-ejection and canopy-jettisoning systems and rocket and missiles systems. A test typical of the many conducted on this track is shown in the lead photograph.

Theoretical consideration of the critical velocities of the old 115-lb rail and beam indicated that at the critical velocity of approximately 2900 fps, sleds weighing 13,500 lb could be operated safely. Higher loads were possible at velocities other than critical.

The new track, however, makes possible a considerable increase in performance and applied load. The new track will handle sled loads of 100,000 lb at the critical velocity of approximately 2900 fps. At lower velocities, allowable vehicle weight increases rapidly in accord with decreased magnification factors.

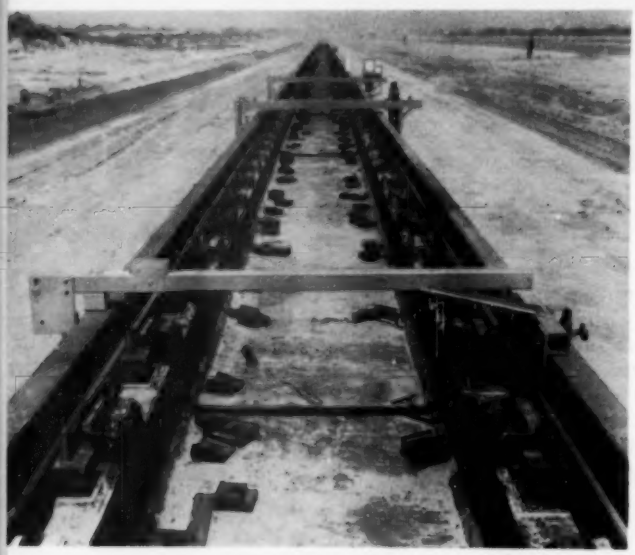

Fig. 12—The special optical and mechanical instruments shown here were used to align the rails

Fig. 13—The hydraulic jacks and tensioning nuts shown here were used to hold the rail at proper tension until clamped in position

Fig. 14—Rail clamped in position. The space between the top of the concrete beam and the bottom flange of the rail between sleepers was filled with asphalt to provide a vibration-dampening media

Roll-Spot Welding

for Ballistic Missiles

Use of seam welder to attach cylindrical parts is found to have a number of advantages over the other methods

BY JAMES K. DAWSON

Introduction

The use of a seam welder to attach cylindrical parts has certain advantages over other methods. The Army Ballistic Missile Agency is now using the method for fabrication of the Jupiter center-section segments. Certain Zee-shaped stiffener rings are attached to the inside of the cylindrical sections, in order to maintain sufficient stiffness in this thin-wall container. Riveting was not considered, due to the leak-proof pressure-tight requirement. Plastic sealents were not considered, due to the incompatibility with liquid oxygen. Fusion welding was not considered, due to the expensive jig and fixtures necessary to prevent warpage.

This left spot welding as the best means of attachment. Inasmuch as there were two spot-welding machines already in production of these and other parts, and an additional load was anticipated, the use of an idle seam welder seemed to have considerable merit, although many difficulties were immediately foreseen.

Operating Problems

The problems included almost every phase of the operation. There was electrode-tip pickup to contend with, which is quite common on soft aluminum. There was the odd shape of a roll-spot weld made on seam-welding wheels. There was the short-circuit arcing which occurs when and if the wheels touched adjacent parts of the assembly during a weld-current cycle. The continual rolling in the positioning fixture would misalign the cylinder on the rubber support rollers, while gouging into the rubber guide roller. Further, continuous operation would heat the disk brake on the rotor motor so that the spot spacing would change with the change in the braking interval.

Some of the minor difficulties included refrigeration water being too corrosive on aluminum; also, the chemical cleaning consistency of the contact resistance area, and the under and over clearance for a cylindrical part. Then, the final requirement of certifying the machine to be used had to be carried out.

Overcoming the Difficulties

Overcoming the major difficulties was the first thing that would have to be accomplished. The

The Jupiter

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Fig. 1—Roll-spot welding wheel

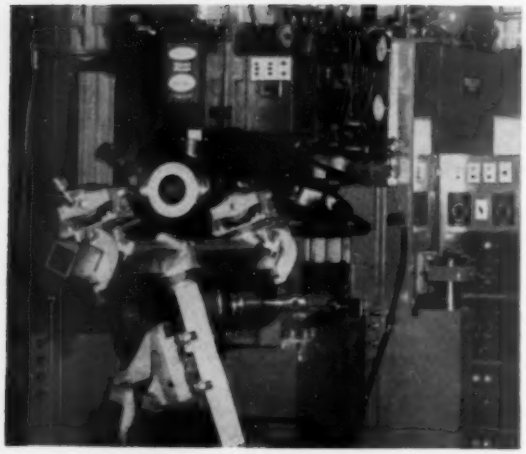

Fig. 2—Insulated wheel

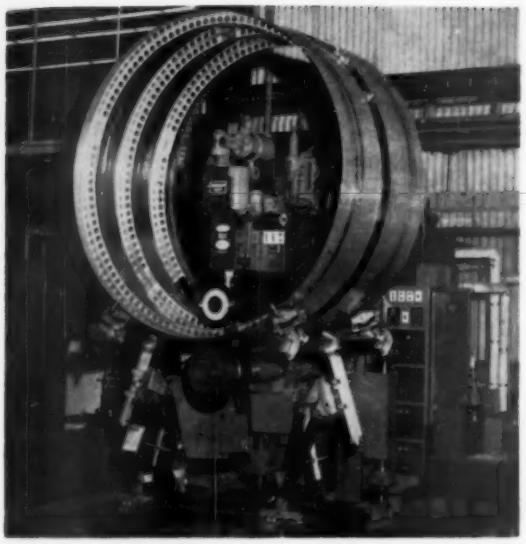

Fig. 3—Jupiter center section

electrode-tip pickup as shown in Fig. 1, was so severe that, once around with the electrode wheels, a cleaning with emery paper was necessary. Wheels of different hardnesses were tried, but no appreciable advantage could be found. Using inserts of stainless-steel shim stock was attempted and found to be successful but impractical, due to the bending of the shim stock and its impossible reuse, in addition to the added alignment problem induced by its necessary guidance. Special cleaning processes did give some hope, but did not eliminate the excessive tip pickup. The best and most attractive method was to reduce the electrode temperature, particularly on the soft aluminum. The water system has to be separated so that the power ignition tubes would not collect, condensate and drip moisture, since the electrodes were cooled with water far below the dew point.

The cleanliness of the spot and the electrodes having been brought under some control, the next improvement was to get the shape of the spot weld rounded up. The radii of the upper and lower electrodes are often used to control the desired direction in which penetration needs to be adjusted, in order to balance out a poorly distributed spot-weld nugget. In this case, the radius of the electrode wheels (that is, across the face of the wheel perpendicular to the diameter curvature) was used to control the shape of the nugget and the surface impressions. By using a planned system of elimination by trial, a pair of radii was found that made satisfactory round spot welds using seam-welding electrode wheels. Considerable success was obtained on various alloys and gages using this method.

Short circuits in electrical welding circuits result in undesirable effects. Using a wheel as a welding electrode does not allow access to confined quarters or difficult locations. In this case, welding was to be inside a flat area of the external leg of a Zee section that is fairly open and accessible. However, the upright leg of this particular Zee could easily touch the upper electrode wheel. An insulation ring, which appears as the white circle in Fig. 2, was introduced. It has a machined, smooth surface which rides freely against the Zee frame, prevents electrical contact and assists the operator for guiding and aligning purposes during a continuous run of circumferential welds.

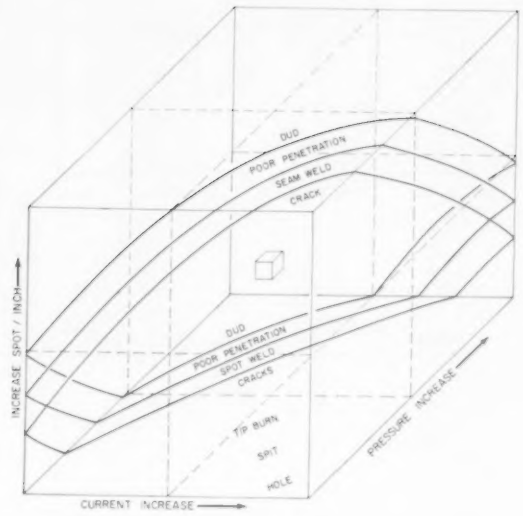

Fig. 4—Roll-spot welding variables

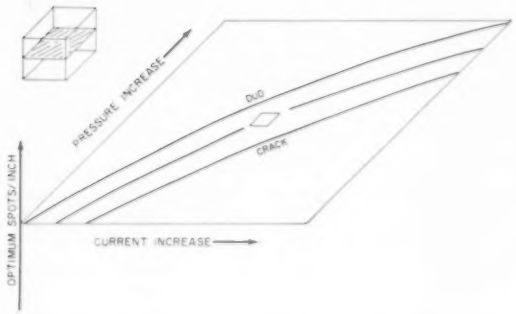

Fig. 5—Current-pressure curved path

Stainless-steel rollers were used to replace rubber guide rollers, thereby making the fixture useable for a continuous run. On a continuous run, the rotor motor would be excited and then released by its brake band; it would be allowed to run during a short spacing interval and then stopped by the same brake. The motor would naturally overheat, and had extra cooling-fan provisions. However, the brake was not cooled externally and, with continuous operation, would heat and swell the parts. This led to a slower release and a quicker stop, thus shortening the spacing interval as time progressed. This interval was important for continuous good welding, as will be discussed later. The brake was eventually kept in adjustment by cooling with a continuous blast of a compressed-air jet.

Some of the plans for improving the conditions and overcoming the minor difficulties are presently being carried out. The adjustment of the refrigeration water temperature, so as to be able to eliminate the external cooling water on the wheel electrode, is being worked out. This will eliminate hand drying by the operator, as well as reduce corrosion in the crevices beneath the Zee sections.

Prevention of tip pickup and burned spots that must be avoided should be improved at the same time. Improved chemical cleaning is always desirable in spot welding. The increase in control over this process usually shows up in making most of the other difficulties easier to handle, such as the tip pickup and burned spots just mentioned. This does not mean that chemical cleaning will solve these problems, but it will assist greatly. The over-all problems of contact resistance, surface life and compatibility for spot welding are subjects for further study. A standard contact-resistance measuring circuit is being used to collaborate the shop measuring devices, and many discrepancies have been encountered. One is the rate of pressure loading, which is under study and perhaps can be brought under control.

There is also the size of cylinder that a seam welder can accommodate under the lower horn or over the top. In Fig. 3 it can be seen that the Jupiter center section was big enough to more than clear the top of large seam welder. However, it is conceivable that a smaller missile or a much larger missile could make positioning for a continuous run in a seam welder most difficult.

After making the proper preliminary provisions, there is always the major task of obtaining a certification setting. A major variable in resistance welding is the amount of heat concentrated or what is commonly referred to as "current." It can be adjusted in many ways on different types of equipment. However, the general adjustment is to increase or decrease the current. Another major variable is pressure before, after and, most important, during welding. Again, the adjustment is to increase or decrease pressure. There is also a much neglected variable which is of major importance to both spot and seam welding alike. This variable is spot spacing, not for joint efficiency, but for machine setting, to overcome shunting between spots to a degree satisfactory enough to allow a good weld nugget to be formed. The spacing may be shortened by increasing the number of spots per inch or increased by decreasing the number of spots per inch.

Examining Fig. 4, it can be seen that an optimum plane of good resistance welds should exist some place among all the possible combinations now available.

More than often, a drawing specifies the number of spots per inch. Taking a fixed spacing as in Fig. 5, it can be seen that the pressure-current ratio for good welding may not be a linear function but a curve which could possibly fit an empirical formula of some type. To the left of this curve, as pressure and current are increased there exists a large area of pressure welds commonly called "duds" because they break easily under impact even when considerable

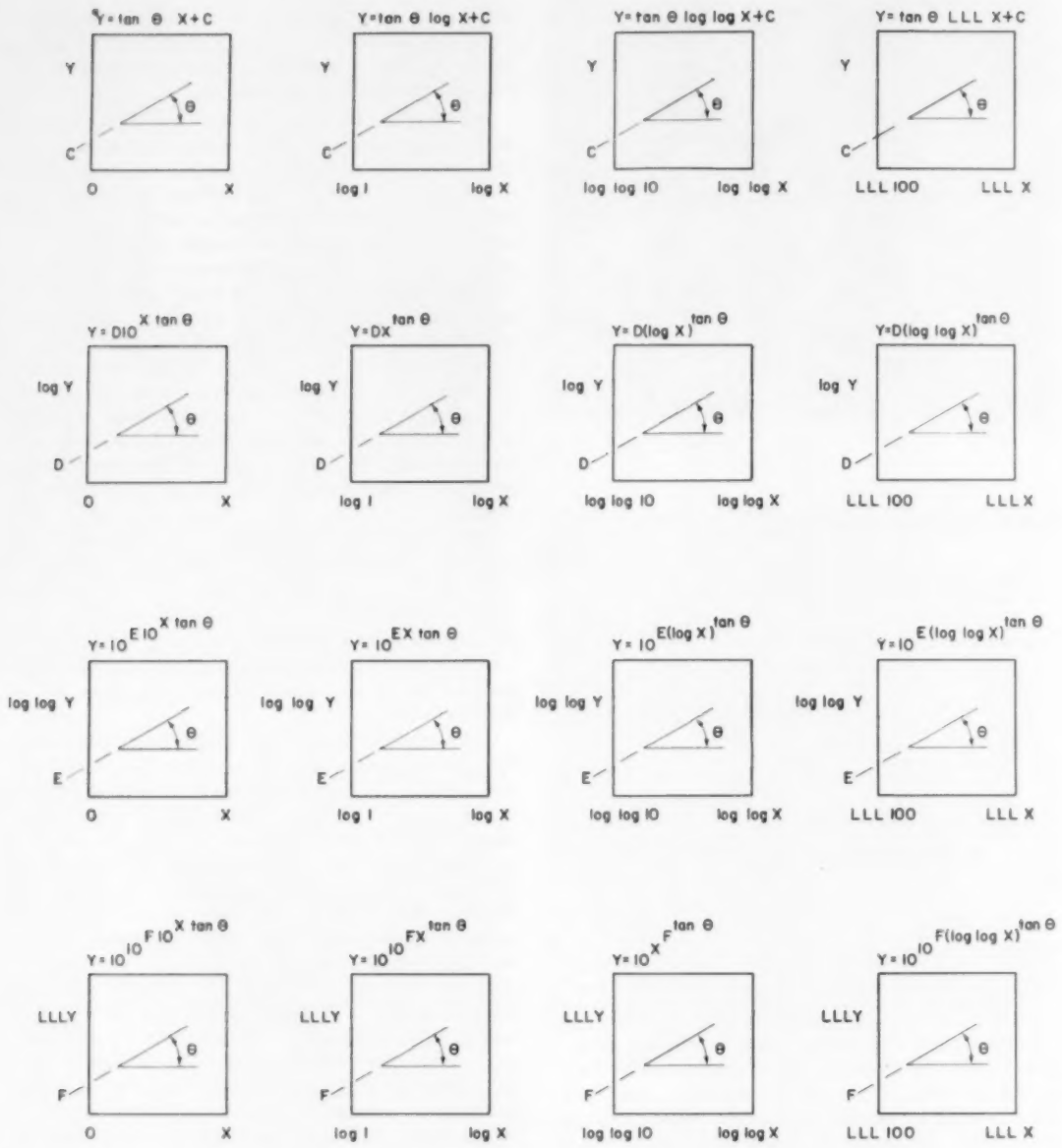

Fig. 6—Possibilities in curve fitting

tensile strength exists, because they have no fusion nuggets. To the right of this curved path, there exists a more closely gathered area of cracked spot welds associated with porosity, spit and tipburn with an increasing danger of blowing a hole. The curve itself should be seen as a two-lane roadway over which one could travel. To take the center of the road is not always possible. To drive on the right of the road the danger of running into a crack or having a "blow out" is there and must constantly be guarded against. On the other hand, to drive on the left side of the road is to encourage the possibility of having an impact-sensitive dud which is something worse than no weld at all, as it gives false hope to both welder and inspector. When viewed even by X-ray, it may appear perfect (no cracks, no porosity).

When pulled by a tensile machine, these duds sometimes pull with more pounds strength than the specifications require. Their statistics are only slightly worse than those of good welds, inasmuch as most welds have a small ring of cohesive bonding just outside the fusion nugget which, if present will

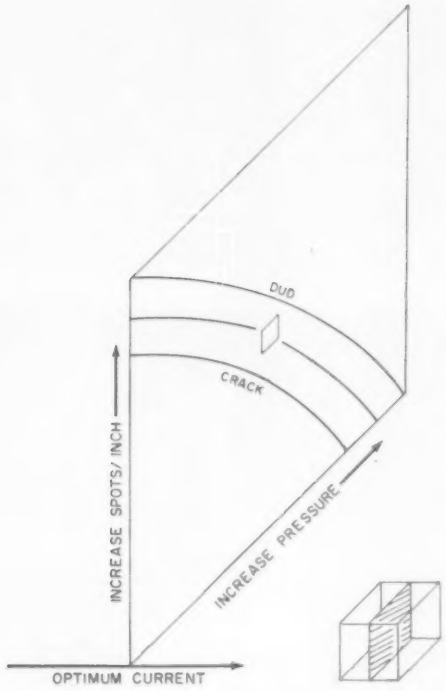

Fig. 7—Pressure-spots/inch curved path

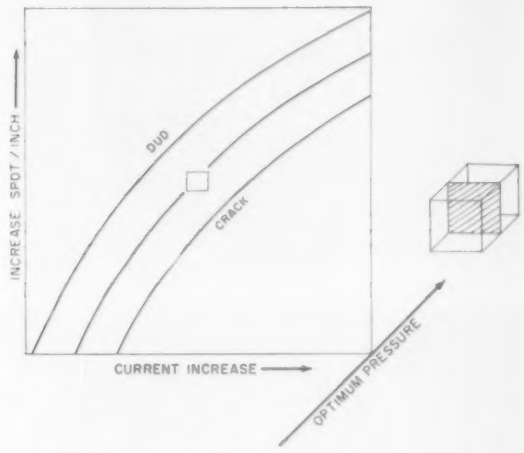

Fig. 8—Current-spots/inch curved path

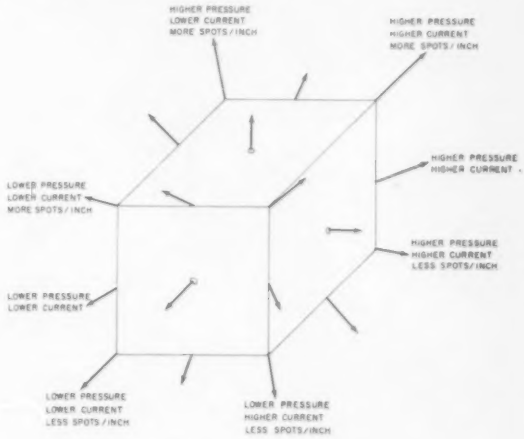

Fig. 9—Roll-spot welding adjustments

distort the statistics of good welds.

There are many possible approaches to fitting a mathematical formula to the curved pathway. Figure 6 outlines the method of graphically analyzing a set of test data by plotting said data on different types of graph papers. The best type for this purpose is the one known as log-log paper. The intercept of the Y-axis, when X is one, gives the log of the equations constant but can be read directly from graph at D. The slope of the straight line represents the exponent of the equation and must be read with a protractor and the tangent derived from the angle θ. Then, $Y = DX^{\tan \theta}$ and $X = KY^{\text{cotan } \theta}$ where K is the intersection of the X-axis.

In Fig. 7, a schematic view of what takes place can be observed when the available current is cut short and fixed like the upper limit of a small machine. Naturally in this figure, the tangent of the angle would be negative due to the reverse slope.

In Fig. 8, a fixed or optimum pressure is considered and the effect of the other two variables can be studied.

Should the little cube, which appears as a square in the last three figures, be the best location for a certain alloy and gage combination, then the problem is how to get there. Figure 9 shows some of the possibilities that are open to the operator, if he knows where he is and where the optimum is from there. Going back to Fig. 4, this over-all view of the situation helps. The near lower left-hand corner contains small sound welds good for thin gage material. The upper right-hand rear corner has the larger welds for heavier gage material.

Conclusions

The results of utilizing the seam-welding equipment were gratifying in that the certification produced above-average results and the spots looked good and were round. There was a time saving of 3 to 1 over spot welding. A conventional spot welder has to raise and lower the upper electrode between each spot. This takes time. Complete automation could reduce the time of positioning between each spot, but it is doubtful if the speed of a rolling electrode could be matched.

Acknowledgment

Acknowledgment for their aid and assistance in this program is hereby made with appreciation to Hans Maus, Laboratory director; O. Eisenhardt, Branch chief; C. Green, Welding foreman. Others include W. Wilson, R. Brown, W. McCampbell, H. Thomas, Stevenson and Jackson.

Practical Welder and Designer

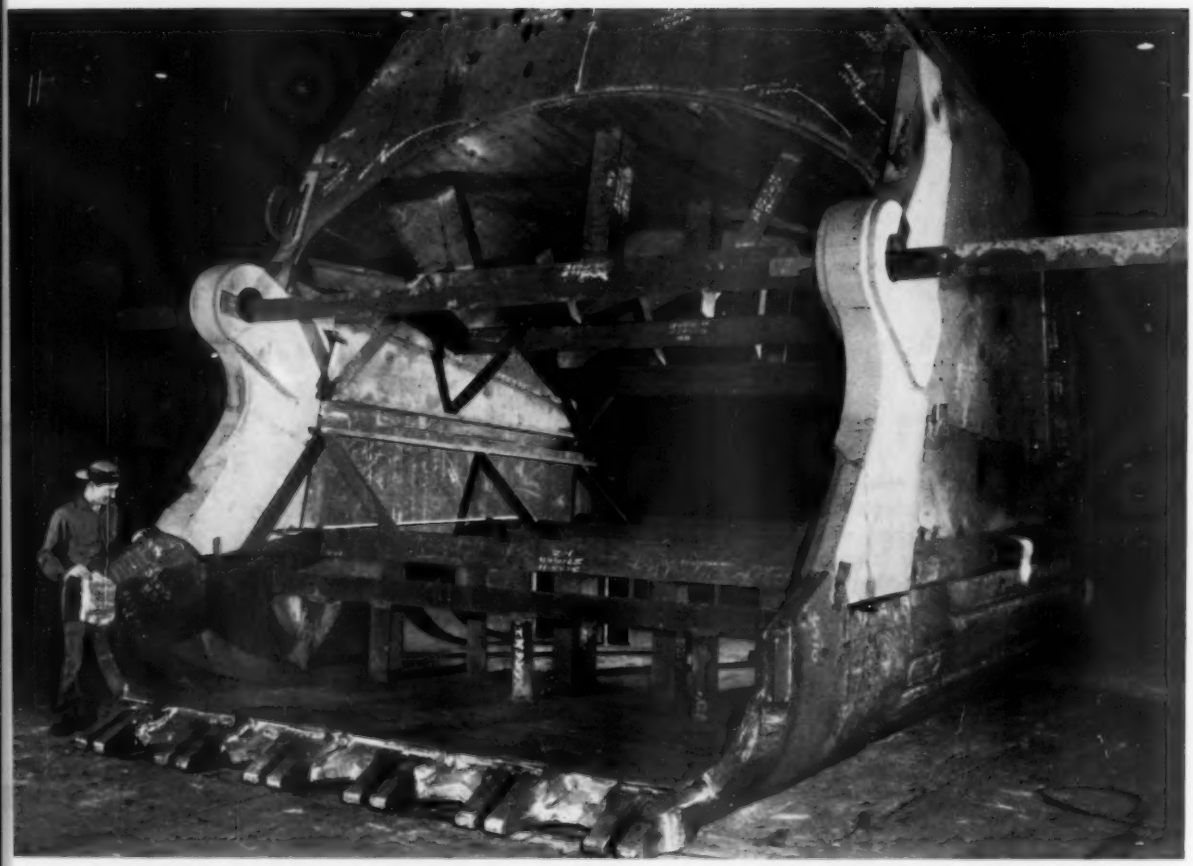

Fig. 1—This big dipper, capacity of which is 70 cu yd, is typical of the many weldments that go into one of the largest shovels ever built

Alloy Steels for Big Shovel Welded by Semiautomatic Submerged Arc

BY ALFRED TOZER

Semiautomatic submerged-arc welding tops the job in building components for Marion Power Shovel Co.'s latest behemoth, an electric power shovel with a 70 cu yd capacity—big brother to the company's famed "Mountaineer" that would scoop up a mere 60 cu yd of dirt in a single bite. Of the same type as its predecessor, the "big dipper" is necessarily built to withstand rigorous all-weather use and the destructive tendencies of working rough terrain.

The dipper itself, Fig. 1, is of all-welded construc-

ALFRED TOZER is Welding Engineer at the Lincoln Electric Co., Marion, Ohio.

Fig. 2—This high-tensile alloy-steel rack is semiautomatic submerged-arc welded to the crowd handle. The lightweight, manually guided conical gun holds the flux and feeds it simultaneously with the electrode for continuous, smooth, high-quality welds

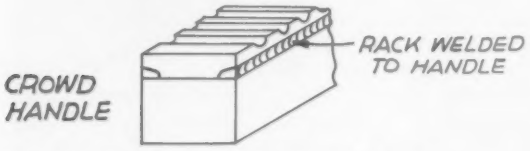

Fig. 3—Welding of the toothed rack section to the crowd handle is facilitated by a J-groove extending along each side

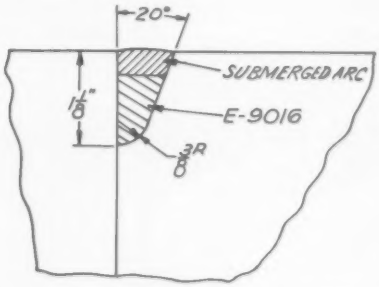

Fig. 4—The J-groove joint is first filled with E-9016 weld metal, which is then covered with a submerged-arc weld made with mild-steel wire and suitable flux

Fig. 5—The metal arc is completely submerged by the flux fed automatically with the electrode. Process offers a high operator-safety value in addition to welding efficiency

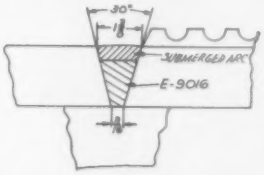

Fig. 6—The semiautomatic submerged-arc welded cover pass leaves a clean, smooth surface. Excess flux is quickly brushed or shaken off

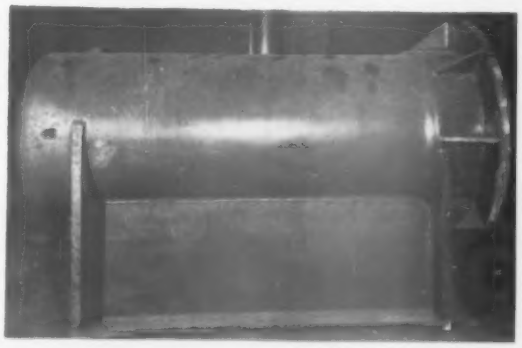

Fig. 7—Power shovel is equipped with one of these husky leveling jacks at each of four corners. Jack cylinder is fabricated completely by multiple-pass semiautomatic submerged-arc welding

tion, being fabricated from T-1 alloy-steel plates. T-1 is a high-strength, low-carbon, quenched-and-tempered steel having good welding characteristics, but demanding much from the weld metal to match its own high physicals.

The crowd handle rack, Fig. 2, is machine cut to tooth form and hardened prior to assembly. The plate material for the crowd handle is another high-tensile alloy steel, ASTM A-242. Nominal properties include 70,000 psi tensile strength and 50,000 psi yield strength.

The rack is welded to the crowd handle by means of side J-groove joints as sketched in Figs. 3 and 4. The joint is partially filled by covered manual electrodes of the E-9016 type, and a cover pass is then put in with the semiautomatic, submerged-arc process. This process is employed for the large cover pass because of its fast deposition of the large amount of weld metal required to fill the joint. The submerged-arc process also produces a smooth, clean surface over the joint.

The transverse joint, shown close up in Fig. 5 and sketched in Fig. 6, is a V-groove weld built up in much the same way as the side joints. Semiautomatic guns, shown being used, feed $^{5}/_{64}$-in. mild-steel electrode and flux simultaneously. Welds are made using 440 amp current; 32 v dc; straight polarity (electrode negative).

Another typical weldment in Marion's giant shovel is the hydraulic leveling-jack cylinder, Fig. 7. This alloy-steel member is completely multiple-pass semiautomatic submerged-arc welded. The shovel is equipped with one of these leveling jacks at each of its four corners.

Fig. 1—Making a web-to-web weld on the steel structure of the parking deck

Welded Design Leads to Low-Cost Structural-Steel Parking Deck

Fig. 2—Direct web-to-column welds were used. Special clips were installed in a vertical position

A parking deck for 126 cars has been built in Bethesda, Md., at a cost of $992 per car space. This low cost was achieved in spite of drilled-in-pier foundations and the BOCA code requirement of fireproofing the steel which was below grade.

The building consists of a $3^1/_2$-in. concrete slab on 24-gage metal form on a structural-steel frame. Cantilever construction was used adjacent to the longer spans of the main girders; 24,000 psi working stress was used at points of negative moment. All beam connections were made with special clips (see Figs. 1 and 2) and direct web-to-web or web-to-flange welds. Columns were welded directly to beam flanges without using cap or base plates (see Fig. 3). Web stiffeners were welded to the beams below the columns. All column and beam ends were sawed to provide a neat fit (see Fig. 4).

It has been estimated that a 10% steel saving was effected by the use of cantilever design and the elimination of connection angles and cap and base plates.

The fabrication of the required 80 tons of steel

Based on a story by B & M Welding & Iron Works, Inc., Gaithersburg, Md.

Fig. 3—Columns were welded directly to beam flanges without cap or base plates

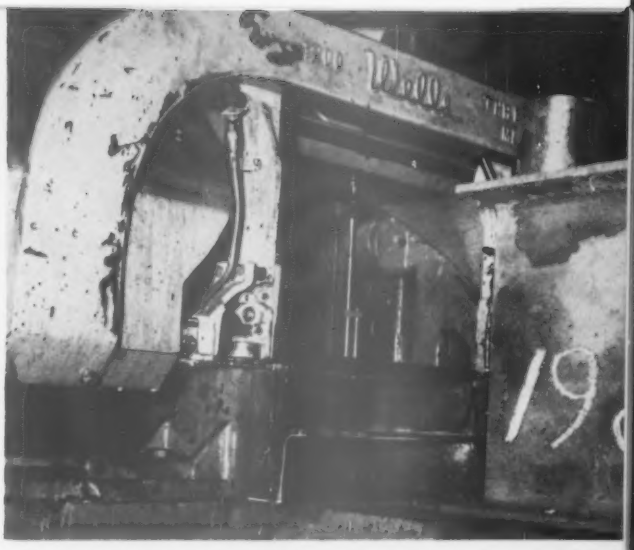

Fig. 4—All beam and column ends were sawed to provide a neat fit

was simplified by using the special clips in an unusual way. All intermediate beams which framed into girders would have required a deep cope and consequent shear reinforcement if the clips had been welded to their bottom flanges. One clip was welded in a vertical position to the web of the girder, and the mating clip was welded to the web of the beam. When the beams were erected, the riggers landed them, the ground men held them in position with two tag lines and then the riggers tack welded them in place.

The only holes and bolts required for the job were for the connections of the cantilever beams and the anchor bolts.

The fabricator located and held the columns in place by using what he calls "chill rings." These rings are short pieces of pipe which are shop welded to the beam flanges. The weld is made around the inside of the ring. The chill rings fit inside the pipe columns and hold them until they can be field welded. The only overhead field welding required in the job was at the tops of the columns.

Three weeks were required from start of fabrication to completion of field welding (see Fig. 5).

Fig. 5—Eighty tons fabricated, erected and welded in three weeks

Thirteen Miles of Welds in West Coast Loading Dock

Two gas-shielded metal-arc welding machines made 68,000 lineal feet of fillet welds in low-carbon steel sheet piling needed to construct a large cellular bulkhead for a 2600-ft loading dock at Marine Terminal No. 2 of Richfield Oil Corp. in Long Beach, Calif.

Each of the 70 cells in the dock averaged 31 ft across the center and 31 ft in length, while sheet piling ranged from 45 to 100 ft in length. Inside and outside welds on the cells were 4 ft, 9 in. long, while welds on both sides of the diaphragms were 9 ft long.

All welding was done in a vertical position, with two 500-ampere rectifier units supplying the gas-shielded metal-arc machines with power.

In order to make the gas-shielded metal-arc machines even more portable for welding the diaphragms, both the wire drive units and wire reels were separated from the control units and suspended under the gantry bridge. After all welding was completed and a final elevation established, the tops of the sheet piling were powder cut to a finish line.

The $^{1}/_{16}$-in. diam steel wire used to produce the welds in the low-carbon steel, contains a special deoxidizing agent that imparts a fine grain to the weld metal. Inert argon gas was used in the operation to protect the weld zone from contamination by the atmosphere.

Based on a story by Linde Co., New York, N. Y.

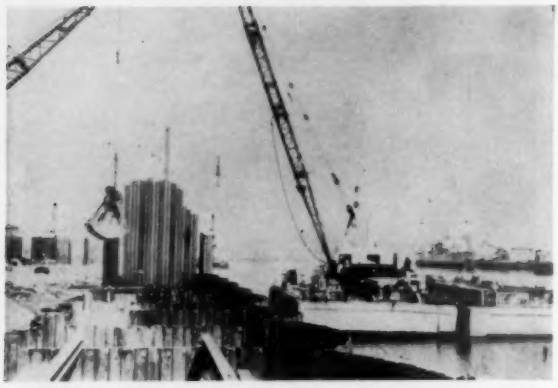

Fig. 1—Here are eight of the 70 cells eventually used to construct the 2600-ft loading dock for Richfield Oil Corp. Note the diaphragms in place between the cells

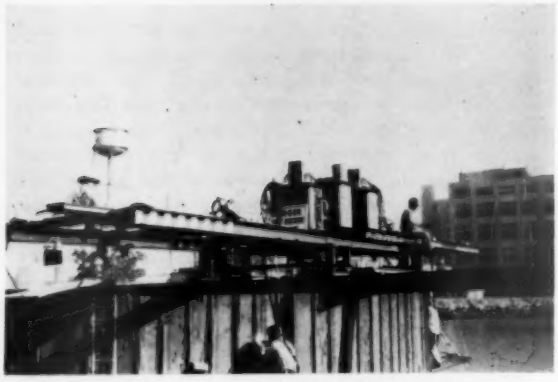

Fig. 2—An operator completes a vertical weld on one of the cells. The 500-amp rectifier units, which supplied the welding power, are situated on the gantry bridge

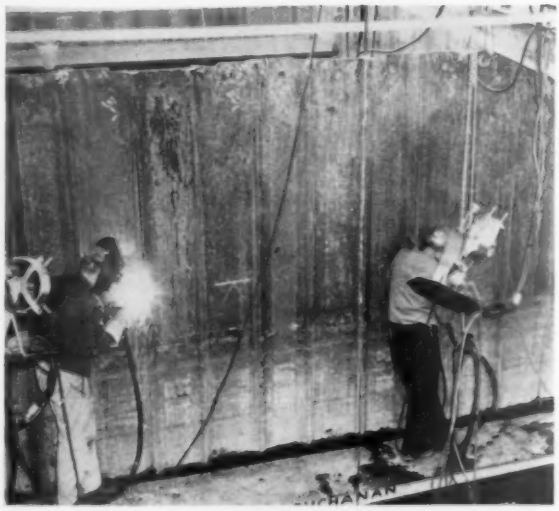

Fig. 3—Two operators simultaneously weld a diaphragm. The wire-drive units and wire reels are suspended under the gantry bridge for making the vertical, 9-ft welds

Using a magnetic-flux gas-shielded welding machine, an operator prefabricates pot ends for steel melting pots

Magnetic-Flux Gas-Shielded Welding 3 to 1

BY C. F. CROWSON

One magnetic-flux gas-shielded welding machine has replaced three covered-electrode machines in the production of melting pots at American Bridge Division of United States Steel Corp., Birmingham, Ala.

In combination with the submerged-arc welding process, magnetic-flux gas-shielded welding reduced distortion and lowered operating costs as compared with the covered-electrode process used previously at this plant.

These huge melting pots are used in aluminum reduction plants as electrolytic cells for reducing bauxite to aluminum. The pots, which measure about 28 ft long, 14 ft wide and 4 ft high, are made from type A-7 structural-quality steel, $^5/_8$ and $^3/_4$ in. thick. The plates are prepared with oxygen-cutting apparatus, then bent and formed to shape.

Magnetic-flux gas-shielded welding is used to prefabricate the pot ends (see figure above) and to make other short welds within the pot. A magnetic-flux gas-shielded welding machine is used with carbon-steel wire at a current setting of 440 amp, 30 v, DCRP. Submerged-arc welding is used to make the longitudinal seams in assembling the pot.

In addition to utilizing the greater speed of magnetic-flux gas-shielded welding, the fabricator took advantage of the process' greater penetration characteristics by beveling the steel plate to a 45-deg included angle—requiring considerably less weld metal and allowing the joints to be welded in just two passes. This combination of speed and penetration permits a production rate of four pots per day—with $^1/_3$ less labor and equipment as previously required.

C. F. CROWSON is Engineering Service Manager for the Linde Co., Birmingham, Ala.

Society News

MacGuffie Elected President of American Welding Society

Charles I. MacGuffie

Charles I. MacGuffie has been elected president of the AMERICAN WELDING SOCIETY for the 1959–60 fiscal year. The entire slate of new officers was introduced to the SOCIETY's membership at the opening session of the 40th Annual Meeting in Chicago on April 6th. Mr. MacGuffie, currently manager of the Special Products Dept., Air Reduction Sales Co., succeeds Gustav O. Hoglund, whose term as 1958–59 president expires on May 31, 1959. The new officers will assume their new posts on June 1st.

Other new officers are:

First vice-president—R. David Thomas, Jr., president of the Arcos Corp., Philadelphia, Pa.

Second vice-president—A. F. Chouinard, director of Research and Development, National Cylinder Gas Division, Chemetron Corp., Chicago, Ill.

Elected as directors-at-large are: Jay Bland, consulting engineer, Welding and Metallurgy Development, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N. Y.; Frank Singleton, owner, Singleton Welding Supply, Kansas City, Mo.; Charles B. Smith, assistant chief materials and process engineer, Long Beach Division, Douglas Aircraft Co., Long Beach, Calif.; and J. R. Stitt, research and welding engineer, the R. C. Mahon Co., Detroit, Mich.

R. D. Thomas, Jr.

A. F. Chouinard

The following will serve as district directors:

New England (District 1)—George W. Kirkley, welding consultant, Design Department and Nuclear Projects, and welding engineer, Research and Development Department, Electric Boat Division, General Dynamics Corp., Groton, Conn.

North Central (District 3)—Joseph W. Kehoe, manager, Headquarters Manufacturing Metals Joining Section, Westinghouse Electric Corp., Pittsburgh, Pa.

East Central (District 5)—Harold E. Schultz, manager of Applications and Processes Engineering, General Electric Co., Evendale, Ohio.

West Central (District 7)—Lester L. Baugh, welding process engineer, Springfield Works, Allis Chalmers Mfg. Co., Springfield, Ill.

Southwest (District 9)—Clifford L. Moss III, production manager, Wyatt Metal and Boiler Works, Dallas, Tex.

Northwest (District 11)—C. B. Robinson, supervising welding engineer, Process Engineering, Air Reduction Pacific Co., San Francisco, Calif.

The new district representatives who will serve on the National Nominating Committee for the 1959–60 term will be as follows:

F. H. Domina, General Electric Co., Schenectady, N. Y. (No. 1); A. Clemens, Jr., Arcrods Corp., Sparrows Point, Md., (No. 2); M. H. Robinson, Dresser Industries, Inc., Bradford, Pa. (No. 3); Ed A. Holder, Ingalls Shipbuilding Corp,. Pascagoula, Miss. (No. 4); P. J. Rieppel, Battelle Memorial Institute, Columbus, Ohio (No. 5); Kieth Sheren, Taylor-Thompson

Jay Bland

Frank Singleton

C. B. Smith

J. R. Stitt

DISTRICT DIRECTORS

George W. Kirkley
District 1

Joseph W. Kehoe
District 3

Harold E. Schultz
District 5

Lester L. Baugh
District 7

Clifford L. Moss III
District 9

C. B. Robinson
District 11

Machinery Co., Dearborn, Mich. (No. 6); Leslie S. McPhee, Whiting Corp., Harvey, Ill. (No. 7); A. G. Hedstrom, Kansas City Structural Steel, Kansas City, Kans. (No. 8); Hubert F. Crick, Mosher Steel Co., Houston, Tex. (No. 9); David P. O'Connor, City of Los Angeles, Los Angeles, Calif. (No. 10); and M. M. Griffith, Food Machinery & Chemical Corp., San Jose, Calif. (No. 11).

In addition to the newly elected candidates, the following national officers will continue in office:

Treasurer: H. E. Rockefeller. *Directors-at-large:* J. F. Deffenbaugh, A. E. Pearson, C. M. Styer, R. M. Wilson, Jr., A. A. Holzbaur, D. B. Howard, C. E. Jackson and J. L. York. *District directors:* E. E. Goehringer (No. 2), E. C. Miller (No. 4), J. N. Alcock (No. 6), F. G. Singleton (No. 8) and F. V. McGinley (No. 10).

Since Mr. Singleton has been elected a director-at-large for a three-year term, commencing June 1, 1959, the office of District No. 8 Director, which is now held by Mr. Singleton, will necessitate a replacement for the unexpired term of one year.

Simplified Bylaws Approved by Board of Directors

During the past forty years the SOCIETY bylaws have been frequently modified and expanded. Rules are now included outlining scope and procedures for committees, and for many activities for which the Board of Directors has direct responsibility. In order to create a new standing committee or make any minor change in existing bylaws, it is necessary to print and mail ballots to all members at a cost which may equal one thousand dollars.

Your Board of Directors considered this problem at a meeting held Apr. 17, 1958, and requested the Secretary and members of the Constitution and Bylaws Committee to prepare recommendations covering a simplified set of bylaws and a supplementary set of "operating rules for the Board of Directors." Recommendations in outline form were submitted to and approved by the Board at their June 5, 1958 meeting. These recommendations provided for basic bylaws covering matters of primary interest to all members and "operating rules" covering matters which are properly the concern of the Board and should be subject to change without formal action of the entire membership of the SOCIETY. Final recommendations were given preliminary approval on Oct. 10, 1958, and final approval by the Board on Feb. 19, 1959.

These bylaws, which have been rearranged and simplified so as to reduce the number of Articles from 22 to 12 and the number of Sections from 147 to 60, are printed in this issue of the JOURNAL. The only actual changes in bylaw requirements occur in Article I, Section 1(c)2. where requirements for membership are slightly relaxed, and, in Article I, Section 2(c), the former rule that a member cannot change from the Member grade to the Associate Member grade is omitted.

It is suggested that you review these suggested bylaws and keep your copy for future reference. At a later date you will receive a ballot. Your National Officers and Members of your Board of Directors recommend that you vote approval.

FRED L. PLUMMER

BYLAWS of the AMERICAN WELDING SOCIETY

ARTICLE I
Membership

Section 1. Classes of Members.

(*a*) *List of Classes.* Sustaining Members, Members, Associate Members, Student Members, Honorary Members and Life Members.

(*b*) *Corporate Members.* Members in the following classes shall be considered as Corporate Members of the SOCIETY: Sustaining Members (acting through their representatives), Members, Associate Members, Honorary Members and Life Members. Corporate Members shall have full rights of membership, except that Associate Members shall not hold National office.

(*c*) *Definition of Classes of Members.*

1. *Sustaining Members.* A Sustaining Member shall be an individual or a Corporation, Firm, Partnership, Organization, Association, etc. interested in the art and science of welding and allied processes. In the case of other than individual memberships, the Corporation, Firm, Partnership, etc. shall designate an individual as their voting representative.

2. *Members.* A Member shall be an individual who shall have at least five years of welding experience having a direct bearing on the art or science of welding and allied processes, or an engineering degree.

3. *Associate Members.* An Associate Member shall be an individual interested in the art and practice of welding and allied processes. Associate Members shall have right to vote but not to hold office except in Sections as may be provided for by the Bylaws of the Section.

4. *Student Members.* A Student Member shall be an individual who is in attendance at a recognized College, University, Technical or Vocational School. Student Members shall not have the right to vote or hold office except in Student Chapters as may be provided for by the Bylaws of the Student Chapter. At the termination of his membership anniversary, following the termination of his status as a student, affiliation as a "Student Member" shall cease excepting that student membership of one having been in attendance at a recognized College or University taking a course leading to a degree may be continued for one (1) additional year.

5. *Honorary Members.* An Honorary Member shall be a person of acknowledged eminence in the welding profession, or who may be accredited with exceptional accomplishments in the development of the welding art upon whom the AMERICAN WELDING SOCIETY may see fit to confer an honorary distinction. There shall be at any one time not more than one Honorary Member, for each five hundred (500) members in the grades of Sustaining Member, Member and Associate Member. Not more than two (2) Honorary Members shall be elected in any one fiscal year.

6. *Life Members.* A Life Member shall be one who has served as National President of the Society.

Section 2. Election and Transfer of Members.

(*a*) *Honorary Members.* Nominations for Honorary Membership may be submitted to the Board of Directors, in writing, by any Corporate Member of the SOCIETY. Such nominations shall state the qualifications of the nominees for such membership, and shall be referred to the Honorary Membership Committee for its recommendations. Honorary Members shall be elected at a regular meeting of the Board of Directors by the unanimous vote of the members present, except that no member of the Board of Directors shall vote upon his own admission.

(*b*) *Life Members.* Life Membership shall be automatically conferred upon a member by virtue of his having served as National President of the SOCIETY.

(*c*) *Other Members.* Applications for membership of Sustaining Member, Member, Associate Member and Student Member grades of membership and for change of membership or of Section Affiliation shall be in writing and shall be subject to the approval of the Committee on Admissions. Applicants for new memberships shall be on prescribed forms and shall be submitted to the Secretary of the Section or the Secretary of the SOCIETY, except students at a college or school which has a student chapter shall submit their application to the advisor of the chapter for his approval.

Section 3. Change of Section Affiliation.

A Corporate Member, in good standing, who desires to transfer affiliation from one Section to another, as permitted in Article III, Section 1, shall make application therefor to either the Secretary of the SOCIETY or the Secretary of the Section with which he desires to affiliate. Such application shall be passed upon in like manner as an application for membership. A Corporate Member, in good standing, who changes his residence from the territory of one Section to that of another Section shall automatically be transferred to the Section to which he moves, unless the member makes application for membership in a different Section.

Section 4. Termination of Membership and Reinstatement.

(*a*) *Resignation of Members.* A member in good standing may tender his resignation from membership by filing with the Secretary written notice of his intention to resign. No dues paid by the applicant shall be remitted.

(*b*) *Expulsion of Members.* Recommendation may be made to the Board of Directors for the expulsion or suspension of a member charged with conduct inimical to the welfare of the SOCIETY. Such recommendation shall be in writing and signed by ten (10) or more corporate members in good standing, stating specific reasons therefor. If the Board decides that sufficient charges have been presented to warrant expulsion or suspension they shall notify the member of the charges presented against him by mailing a communication to his latest address as it appears in the records of the SOCIETY. He shall then have the right to present a written defense, and to appear for a hearing, in person or by duly authorized representative, before a meeting of the Board of Directors, of which meeting he shall be notified at least thirty (30) days in advance. Not less than two months nor more than four months after such meeting, the Board of Directors shall finally consider the case, and if in their opinion the charges have been sustained, the member may be expelled or suspended for such period as the Board may determine, or he may be permitted to resign.

(*c*) *Dropped for Nonpayment of Dues.* For a period of thirty (30) days following a member's renewal date, the member shall be considered evidently delinquent and at the end of that period, mailing of the WELDING JOURNAL shall cease. The delinquent member will be carried on the rolls of the SOCIETY for two additional months beyond the evidently delinquent period and if dues are not paid within that time, his membership will be removed from the rolls of the SOCIETY on the ninetieth (90th) day following his renewal date. Thirty (30) days previous to the ninetieth (90th) day, the Secretary shall duly notify the member by letter to the latest post office address as it appears on the records of the SOCIETY that if his dues are not paid within a period of thirty (30) days, he shall automatically cease to be a member of the SOCIETY.

(*d*) *Reinstatement.* Any Member or Associate Member who has been dropped for nonpayment of dues shall be eligible for reinstatement only upon the payment of a reinstatement fee and shall not be eligible for admission as a new member.

ARTICLE II
Dues, Fees and Refunds

Section 1. Dues and Fees.

(*a*) *Amount of Dues.* The Annual Dues shall be as follows: Sustaining Members, $150 minimum; Members, $20; Associate Members, $15; Student Members, $5; Honorary Members, none: Life Members, none.

(*b*) *To Whom Payable.* All dues shall be paid to the AMERICAN WELDING SOCIETY, at the National Headquarters Office.

(*c*) *Date of Payment.* The Board of Directors may fix the date on which all dues of members shall become payable, may change such date from time to time, and may provide that dues shall be computed from the date of election to membership provided, however, that the total amount of dues to be paid by any member for any consecutive twelve (12) months shall be determined by the amounts fixed in Section 1 (*a*) of this article.

(*d*) *Exemption of Dues.* Any Member or Associate Member who shall have paid his dues for thirty-five (35) years, or who shall have paid his dues for thirty (30) years and reached the age of sixty-five (65) years, shall thereafter be exempt from the payment of further dues, except that the number of years for which dues were paid as an Associate Member shall be reckoned as nine-tenths (9/10) of their number in the above provisions. (Student Membership years not included.) Such members shall not receive the publications of the SOCIETY but may obtain them at membership subscription prices. (This restriction shall be applicable only to new members joining the SOCIETY after the date of the Bylaw revision of October 22, 1953.)

(*e*) *Initiation Fees.* The initiation fee for Members and for Associate Members shall be $5.00.

(*f*) *Reinstatements Fees.* Any Member or Associate Member who has been dropped for nonpayment may be reinstated upon the payment of a reinstatement fee of $5.00.

Section 2. Refund to a Section.

At the beginning of each fiscal year, each active Section shall receive from the SOCIETY an anniversary payment which shall equal $2.00 for each member but which shall not exceed a total of $100. In addition, at the beginning of each quarter of the fiscal year, each active Section shall receive 20% of the sum collected in dues during the preceding quarter from those of its members who are in the grades of Sustaining Member, Member and Associate Member. Each newly organized Section shall receive the anniversary payment based on membership at that time but less overpayment pro-rated on a monthly basis for the first fiscal year. Refunds shall be paid to the Section with which each member is affiliated at the time when refund payments are due. In computing the refund to a Section, only the annual dues and not the initiation or reinstatement fees shall be considered.

Section 3. Refund to a Student Chapter.

Each active Student Chapter, excepting those which are proprietarily or commercially sponsored, shall receive from the SOCIETY, at the beginning of each academic year, $25 to be used for expenses in promoting the activites of the Chapter.

ARTICLE III
Organization

Section 1. Section Organization.

(*a*) *Organization of a Section and Name.* The AMERICAN WELDING SOCIETY, in pursuance of the objects set forth in its Constitution, provides for the organization of Sections. The name of a Section shall be "The ———— Section of the AMERICAN WELDING SOCIETY."

(*b*) *Section Organization Approval.* The organization of a Section shall be subject to the approval of the Board of Directors.

(*c*) *Minimum New Section Membership.* Not fewer than fifty (50) members or eligible paid applicants for membership in the AMERICAN WELDING SOCIETY, in the Sustaining Member, Member and Associate Member grades may apply for authorization for the organization of a new Section.

(d) *Section Membership.*

1. All Corporate Members residing within the bounds of a Section except those who have joined another Section due to business reasons and all others who have chosen to join the Section shall be members of the Section.

2. Student Members residing within the bounds of a Section and attending a college or school where there is no student chapter may apply for membership in the Section.

(e) *Section Bylaws.* The Bylaws of a Section shall not conflict with any provisions of the Constitution or Bylaws of the AMERICAN WELDING SOCIETY. (Outline of recommended Bylaws for a Section may be procured from the Secretary of the SOCIETY.)

(f) *Requirements of an Active Section.* To maintain an active status, the Section shall:

1. Hold at least three meetings during a fiscal year.

2. Have a total paid membership of twenty-five (25) Corporate Members, and

3. Submit annual reports to the Secretary of the SOCIETY in accordance with the SOCIETY Rules. When a Section becomes inactive, the National Secretary shall report the fact to the National Board of Directors which may disband the Section in accordance with the Rules of the SOCIETY.

(g) *Disbanded and Reinstated Sections.* When a Section is disbanded, the Section Treasurer shall return to the SOCIETY all remaining funds. A disbanded Section may be reinstated by the National Board of Directors in accordance with the Rules of the SOCIETY.

Section 2. District Organization.

(a) *Geographical Districts.* There shall be eleven Districts known as: No. 1—The New England, No. 2—The Middle Eastern, No. 3—The North Central, No. 4—The Southeast, No. 5—The East Central, No. 6—The Central, No. 7—The West Central, No. 8—The Midwest, No. 9—The Southwest, No. 10—The Western and No. 11—The Northwest Districts, the boundaries of which shall be determined by the Board of Directors.

(b) *District Executive Committee.* To facilitate cooperation between the Sections, there shall be an Executive Committee in each District which shall consist of the District Director as Chairman and all Section Chairmen or their appointed alternates, within that District.

(c) *District Nominations.* Before July 1st the District Director, with the approval of the District Executive Committee, shall appoint a District Nominating Committee consisting of a member from each Section in the District and two Members-at-Large, one of whom shall be himself and one of whom shall be the Chairman of the District Nominating Committee of the year previous, if available. The members of this Committee who represent Sections shall be selected from among those who are currently Section Chairmen, Vice-Chairmen, Treasurers or Secretaries. The current District Director shall designate the Chairman of this Committee from among those members who represent Sections. If the Chairman of the year previous is not available, the District Director may appoint as Member-at-Large any individual from any of the Sections in his District who presently or in the past has served as Chairman of a Section. The District Nominating Committee shall report to the National Secretary not later than the first day of November of that year, the name of the nominee they have selected for District Representative on the National Nominating Committee to serve the following fiscal year. A District Representative on the National Nominating Committee shall be selected from among those members in the District who have served as Section Chairmen, Vice-Chairmen, Treasurers or Secretaries, or from among those who have previously held National Office. At the same time, in those years when a District Director is to be elected, the Committee shall report its nomination for District Director. Special Qualifications for this office are defined elsewhere in these Bylaws. When reporting nominations to the National Secretary, the written acceptance of the nominees shall be included with the report and a brief biographical sketch of their nominee for District Director shall also be included. Each year the National Ballot for Nomination of Officers shall include the names of the nominees for District Director and for District Representative on the National Nominating Committee as nominated by the District Nominating Committee.

Only District members, qualified to vote, shall be eligible to vote for their District Director and for their District Representative on the National Nominating Committee.

(d) *Vacancies.* The Executive Committee of each District shall have the power to fill a vacancy in the office of Director of that District and of that District's Representative on the National Nominating Committee, for an unexpired term whenever such vacancy occurs. In case of death, disability or absence of the District Director, the National President may appoint a member of the District Executive Committee to convene the District Executive Committee for this, or for other purposes.

Section 3. Student Chapter Organization.

(a) *Organization of a Student Chapter and Name.* A Student Chapter in affiliation with the AMERICAN WELDING SOCIETY, composed of students of engineering, technical or vocational schools, of recognized standing, may be organized upon favorable vote by the Board of Directors. Authority for the organization o a Student Chapter at any institution shall automatically lapse if not used within one year from the date granted. The name of such an affiliated group shall be "The ———— Student Chapter of the AMERICAN WELDING SOCIETY."

(b) *Student Chapter Organization Approval.* The organization of a Student Chapter shall be subject to the approval of the Board of Directors.

(c) *Qualification for Student Chapter.* To apply for organization, the proposed Student Chapter shall have:

1. An organization of students in a college, university, technical or vocational school of recognized standing.

2. The endorsement of the application by the Head of one of the Engineering Departments of the college or school or the Superintendent (or equivalent) of the technical or vocational school.

3. A minimum membership of fifteen (15) student members or eligible paid applicants for Student Membership in the AMERICAN WELDING SOCIETY.

4. An advisor to the Student Chapter whose duties shall be to consult with and advise the Student Chapter on matters relating to the general conduct of the Chapter. The Advisor shall be a Faculty Member of the college, university or technical school, or instructor or teacher of the vocational school at which the Student Chapter is organized, and he shall be a Corporate Member of the SOCIETY.

(d) *Student Chapter Membership* (Present Article VII, Section 4). All Student Members attending a school at which there is a Student Chapter shall be members of the Student Chapter.

(e) *Student Chapter Bylaws* (Present Article VII, Section 8). The Bylaws of a Student Chapter shall not conflict with any provisions of the Constituton or Bylaws of the AMERICAN WELDING SOCIETY.

(f) *Requirements of an Active Student Chapter.* To maintain an active status, a Student Chapter shall:

1. Hold at least three (3) meeting during the academic year and

2. Report to the Secretary of the SOCIETY in accordance with the Rules of the SOCIETY.

(g) *Disbanded and Reinstated Student Chapters.* A Student Chapter which becomes inactive may be disbanded by the Board of Directors in accordance with the Rules of the SOCIETY. When a Chapter is disbanded, the Chapter Treasurer shall return all remaining funds to the SOCIETY. Disbanded Student Chapters may be reinstated by the Board in accordance with the Rules of the SOCIETY.

ARTICLE IV
National Officers, Their Qualifications and Duties

Section 1. List of Officers.

The National Officers of the SOCIETY shall be a President, three Vice-Presidents, a Treasurer, thirteen Directors-at-Large, eleven District Directors, a Secretary and two Past-Presidents.

Section 2. President.

The President, after being duly nominated, shall be elected by the SOCIETY's corporate membership for a term of one year. He may at any time be re-elected for a term of one year, but in no case shall he serve in this capacity for more than two years. To be eligible for this office, a candidate must have served as a National Vice-President for at least one year or served as any other National officer, other than Secretary, for at least two years.

The President shall have general supervision of the affairs of the SOCIETY, under the direction of the Board of Directors. He shall serve as Chairman of the Board of Directors, Chairman of the Executive and Finance Committee, and shall be a member, *ex officio*, of all Councils and Standing and Special Committees, with the exception of the Nominating Committee. He shall preside at meetings of the SOCIETY and shall perform such other duties as provided for elsewhere in these Bylaws or as may be assigned to him by the Board of Directors. He shall submit a report of the operation of the SOCIETY for the fiscal year to the Board of Directors at their last regular meeting of the fiscal year and to the members at the annual meeting.

Section 3. Vice-Presidents.

Three Vice-Presidents without seniority, after being duly nominated, shall be elected by the SOCIETY's corporate membership for a term of one year. Vice-Presidents may be re-elected for a second or a third term at any time, but in no case shall an individual serve more than three terms in this capacity. To be eligible for Vice-President, a candidate must have served at least one year as a National Officer, other than Secretary.

Each Vice-President shall serve as a member of the Board of Directors, a member of the Executive and Finance Committee, and as Chairman of a Functional Council as designated by the Office Assignment Committee. He may be appointed by the President, with the approval of the Board of Directors, for the duration of his term to any office in the Standing or Special Committees, except the Nominating Committee. In the event of absence or disability of the President, the Vice-President, who is Chairman of the Districts Council, shall preside at meetings of the SOCIETY, the Board of Directors, the Executive and Finance Committee, and discharge the duties of the President. Vice-Presidents shall perform other duties which may, from time to time, be assigned to them by the President, with the approval of the Board of Directors.

Section 4. Directors-at-Large.

There shall be thirteen Directors-at-Large. Each year four Directors-at-Large, who have been duly nominated, shall be elected by the corporate members of the SOCIETY to serve for a term of three years. Every third year an additional Director-at-Large shall be similarly nominated and elected to serve for a term of three years. Directors-at-Large shall not be eligible for re-election to the same office until at least one full term of three years shall have elapsed after the end of their respective terms. To be eligible for this office, a candidate shall previously have held office as Chairman, Vice-Chairman, Treasurer, or Secretary of a section; as Chairman, Vice-Chairman, or Secretary of a National Standing, Technical or Special Committee; or as District Director or Director-at-Large.

Directors-at-Large shall serve as members of the Board of Directors and as members of a Functional Council to which they have been appointed by the President after consideration of the recommendations of the Office Assignment Committee. Directors-at-Large may be appointed by the President, with the approval of the Board of Directors (in meeting or by letter ballot) to one or more one-year terms as members of the Executive and Finance Committee. They also may be appointed by the President, with the approval of the Board of Directors, for any part or for the duration of their terms to any office in the Standing and Special Committees, with the exception of the Nominating Committee.

Section 5. District Directors.

There shall be eleven District Directors, one from each of the SOCIETY's Districts. District Directors shall be duly nominated and elected by their respective Districts for a term of three years. District Directors from Districts 1, 4, 7, 10 shall regularly be elected in the same calendar year beginning with the election following the adoption of this Bylaw. Districts 2, 5, 8, 11 shall regularly be elected in the calendar year following the forementioned District Directors, while those from District 3, 6, 9 shall regularly be elected in the next following calendar year, or two years after the election of District 1, 4, 7, 10 Directors. An individual shall not be eligible for re-election to the same office until at least one full term of three years has elapsed following his term of service. To be eligible for this office, a candidate must have served as Chairman, Vice-Chairman, Treasurer, or Secretary of a section; as Chairman, Vice-Chairman or Secretary of a National Standing, Technical or Special Committee; or as

District Director or Director-at-Large.

Section 5 (*a*) **(Temporary Bylaw)** (to Expire When All District Directors Have Been Regularly Elected in Accordance with Foregoing Schedule).

District Directors who are in office at the time of adoption of this Bylaw and who, under the previous Bylaw, have more than one year of the term to which they were elected remaining at that time, shall continue in office, but only until the first regularly elected Director for their district shall assume office under this Bylaw. For other Districts, candidates shall be duly nominated and elected at the first election following adoption of this Bylaw for interim terms of such duration of one or two years as is required to fill the office until a regular election for that District can be held in accordance with the aforementioned schedule.

Other provisions of these Bylaws notwithstanding, District Directors who serve interim terms or extended terms or who have had the terms to which they were elected shortened by this Bylaw change, shall be eligible for re-election to full terms of office, after which they become subject to all provisions of the new Bylaws.

District Directors shall serve as members of the Board of Directors and as members of the Districts Council. District Directors may be appointed by the President after consideration of the recommendations of the Office Assignment Committee, to serve one-year terms as members of the Administrative, the Technical or the Publications and Promotions Council. District Directors may be appointed by the President, with the approval of the Board of Directors (in meeting or by letter ballot), to one or more one-year terms as members of the Executive and Finance Committee. They also may be appointed by the President, with the approval of the Board of Directors, for any part or for the duration of their terms, to any office in the Standing or Special Committees, with the exception of the Nominating Committee.

A District Director shall supervise and promote the affairs of the SOCIETY in his district in accordance with these Bylaws and under the rules and direction of the Board of Directors.

Section 6. Past-Presidents.

Two Past-Presidents shall serve as National Officers for terms of one year each. The immediate Past-President shall automatically fill one of these offices and in the event of the immediate re-election of the SOCIETY's President, he shall serve a second term of one year. The second Past-President Office shall be filled by appointment by the President-elect from among other Past-Presidents, with the letter ballot approval of the incoming Board of Directors.

The immediate Past-President shall be a member of the Board of Directors and of the Executive and Finance Committee. He shall serve as Chairman of the Administrative Council and as a member of the National Nominating Committee. He may be appointed by the President, with the approval of the Board of Directors, to any office for the duration of his term in the Standing and Special Committees.

The other Past-President Officer shall be a member of the Board of Directors and of the Districts Council. He may be appointed by the President, with the approval of the Board of Directors, to any office for the duration of his term in the Standing and Special Committees.

Section 7. Treasurer.

The Treasurer shall be appointed to office for a term of three years. Appointment shall be made by the President, with the approval of, first, two-thirds of the total membership of the Executive and Finance Committee (in meeting or by letter ballot) and, second, the majority of the Board of Directors (in meeting or by letter ballot). The appointment shall be made by the January 31st prior to the June 1st at which the Treasurer is to take office. To be eligible for this office, a candidate must be a member of the SOCIETY, must be frequently available to National Headquarters and should be of executive status in business or industry with leanings or experience in financial affairs. The Treasurer may be reappointed for additional terms.

The Treasurer shall be a member of the Board of Directors, of the Executive and Finance Committee, and of the Reserve Funds and other fund committees. He may be appointed by the President, with the approval of the Board of Directors, and for the duration of his term to any office in the standing and Special Committees.

(*a*) The Treasurer shall receive all monies and deposit the same, to the credit of the SOCIETY, in such depositories as may be designated by the Board of Directors.

(*b*) He shall disburse the funds of the SOCIETY as may be ordered by the Board of Directors, obtaining the proper vouchers for such disbursements.

(*c*) He shall furnish, at regular intervals, to the Board of Directors a statement of receipts and expenditures under their several headings and also a statement of monthly balances. He shall make an annual report and such other reports as may be prescribed by the Board of Directors. The annual report shall be certified by a competent public account selected by the Board of Directors.

(*d*) He shall give the SOCIETY a bond in a sum, and with one or more securities as required by, and satisfactory to, the Board of Directors for the faithful performance of the duties of this office and the restoration to the SOCIETY in the case of his death, resignation or removal from office of all books, papers, vouchers, money or other property of whatever kind in his possession belonging to the SOCIETY. The cost of the bond shall be borne by the SOCIETY.

Section 8. Assistant Treasurer.

The Board of Directors may appoint an Assistant Treasurer for a term of one year.

The Assistant Treasurer shall perform those duties delegated to him by the Treasurer and in the absence or disability of the Treasurer shall act instead of the Treasurer.

Section 9. Secretary.

A Secretary shall be appointed by the Board of Directors for a term of one year.

(*a*) The Secretary shall be, under the direction of the President and the Board of Directors, the Chief Executive Officer of the SOCIETY.

(*b*) He shall be, *ex officio*, a member of all committees, except the Executive and Finance, Admissions, Nominating, Constitution and Bylaws, Code of Principles of Conduct, Awards, Honorary Membership, Reserve Funds and Special Committees unless so ordered by the Board of Directors.

(*c*) He shall engage such employees as may be authorized by the Board of Directors and shall manage all activities of staff officers and employees.

(*d*) He shall supervise and promote the affairs of the SOCIETY, nationally and internationally, under the direction of the President and the Board of Directors.

(*e*) He shall perform such other duties as may be assigned by the Board of Directors.

Section 10. Assistant Secretary.

The Board of Directors may appoint an Assistant Secretary for a term of one year.

The Assistant Secretary shall perform those duties delegated to him by the Secretary and in the absence or disability of the Secretary shall act instead of the Secretary.

ARTICLE V

Management, Audit and Financial Responsibilities

Section 1. Board of Directors.

The affairs of the SOCIETY shall be managed by a Board of Directors consisting of the following Officers of the SOCIETY: President, three Vice-Presidents, Treasurer, thirteen Directors-at-Large, eleven District Directors and two Past-Presidents. The President shall serve as Chairman of the Board.

Section 2. Duties of Board of Directors.

The Board of Directors shall have the power:

(*a*) To manage the affairs of the SOCIETY, except as otherwise provided by law, or by these Bylaws.

(*b*) To delegate to the Executive and Finance Committee general supervision of the SOCIETY's affairs.

(*c*) To purchase or otherwise acquire for the SOCIETY any property rights and privileges which the SOCIETY is authorized to acquire, or to dispose of such, at such prices and on such terms and conditions and for such considerations as they think fit.

(*d*) To appoint Executive Officers and fix their salaries.

(*e*) To determine who shall be authorized to sign, on behalf of the SOCIETY, notes, receipts, acceptances, endorsements, checks, releases, any and all contracts and other documents, and shall make such authorization.

(*f*) To create and/or approve rules governing the scope and limitations of activities of officers and committees provided such rules do not conflict with other provisions of these Bylaws.

(*g*) To amend portions of the Bylaws in accordance with the provisions of Article XII.

(*h*) To perform such other acts as may be necessary to carry out the purpose of the SOCIETY.

Section 3. Vacancies in Board of Directors.

In each case of a vacancy occurring in the Board of Directors through death, resignation, disqualification or other cause, the remaining Directors, by ballot, may elect or appoint a successor to hold office for the unexpired portion of the term of the retiring Director; and in the event that a quorum of the Board of Directors does not exist, the affirmative vote of a majority of the remaining Directors shall become effective. However, if the retiring Director is a District Director then the vacancy shall be filled as provided for in Article III, Section 2 (*d*).

Section 4. Executive and Finance Committee.

The Executive and Finance Committee is a committee of the Board of Directors and shall consist of the President as Chairman, the three Vice-Presidents, each of whom is Chairman of a functional council elsewhere established in these Bylaws, the Past-President who is the Chairman of the Administrative Council elsewhere established in these Bylaws, the Treasurer and three Directors. The Directors who serve on this Committee shall be appointed by the President with the approval of the Board of Directors.

Section 5. Duties of the Executive and Finance Committee.

The Executive and Finance Committee upon delegation of power to act by the Board of Directors shall have general supervision of the SOCIETY's affairs. It shall supervise and control budgets, reserve and other funds, member dues and benefits, and headquarters affairs. The four functional councils of the Board of Directors, described in the next section of this Article, shall report to this committee. The following committees shall report to the Executive and Finance Committee: Manufacturers, Reserve Funds, AWS Past-Presidents, Headquarters Housing, and any other when designated so to report.

Section 6. Functional Councils.

(*a*) There shall be four Functional Councils made up of members of the Board of Directors. These shall be named the Administrative Council, the Technical Council, the Districts Council, and the Publication and Promotion Council. The Functional Councils report to the Executive and Finance Committee. They are responsible for advising and assisting the Executive and Finance Committee in their respective areas of activity. Each council through its Chairman has representation on the Executive and Finance Committee. The members of the four Councils shall be appointed by the President with the approval of the Board of Directors.

(*b*) In the event that a Functional Council disagrees with action taken, directive issued or decision made by the Executive and Finance Committee, the Council may, upon unanimous consent of its members, take their appeal or recommendation to the whole Board of Directors, which body shall act as it sees fit.

Section 7. The Administrative Council.

(*a*) The Administrative Council shall consist of five members made up of one Past-President as Chairman, three Directors-at-Large, and one District Director. This Council shall oversee SOCIETY policies, relations, and election procedures. It shall report and make recommendations to the Executive and Finance Committee.

(*b*) The following committees shall report to this Council: Admissions, Awards, Code of Principles of Conduct, Constitution and Bylaws, Honorary Membership, National Nominating and Public Relations, Welder Registration and Certification, and any other when designated so to report.

Section 8. The Technical Council.

(*a*) The Technical Council shall consist of seven members made up of a Vice-President as Chairman, five Directors-at-Large and one District Director. This Council shall oversee technical policies, technical direction and technical ex-

ploration and shall report and make recommendations to the Executive and Finance Committee.

(*b*) The following committees shall report to this Council; Educational Activities, Technical Activities, Welding Handbook, the Welding Journal and any other when designated so to report.

Section 9. The Districts Council.

(*a*) The Districts Council shall consist of thirteen members, made up of one Vice-President as Chairman, eleven District Directors and one Past-President. This Council shall oversee District and Section activities, including membership, and shall report and make recommendations to the Executive and Finance Committee.

(*b*) The following committees shall report to this Council: Membership, Member Classes and any other when designated so to report.

Section 10. Publications and Promotions Council.

(*a*) The Publications and Promotions Council shall consist of seven members made up of one Vice-President as Chairman, five Directors-at-Large and one District Director. This Council shall oversee National publications, promotions and convention activities, and shall report and make recommendations to the Executive and Finance Committee.

(*b*) The following committees shall report to this Council: Convention, Exposition, Publicity, Technical Papers and any other when designated so to report.

Section 11. Audit.

The financial accounts of the SOCIETY shall be audited annually, as soon as possible after the close of the fiscal year, by a Certified Public Accountant, selected by the Board of Directors.

Section 12. Bonds.

All of those authorized to sign checks and other financial documents and those handling the monies of the SOCIETY shall be bonded. The cost of the bonds shall be borne by the SOCIETY.

ARTICLE VI
Nomination and Election of National Officers and Representatives

Section 1. Eligibility for National Elective Office.

Members eligible for National Elective Office shall be Sustaining Members, Members, Honorary Members or Life Members. They shall have been a Corporate Member of the SOCIETY for a period of at least three (3) years.

Section 2. Nominations.

Nominations, except for Secretary, Assistant Secretary and Assistant Treasurer, shall proceed as follows:

(*a*) Nominations for District Directors and for District Representatives on the National Nominating Committee shall be made by the District Nominating Committees (see Article III, Section 2 (*c*)). The National Nominating Committee shall select nominees for the other offices falling vacant (see Article VIII, Section 1). The names of the nominees for each office, with a brief biographical sketch of each (except for nominees to the National Nominating Committee), shall be published in the December issue of the WELDING JOURNAL of the AMERICAN WELDING SOCIETY.

(*b*) The Secretary shall mail, on or before the 26th day of December of each year, to each member entitled to vote, a notice that nominations for officers must reach the Secretary not later than the 26th day of January, unless this date falls upon a Sunday or a holiday, at which time the closing date shall be the following day. This notice shall outline the vacancies of elective offices that shall be filled at the next regular election and request nominations for such offices. It shall also contain the names of the members of the National Nominating Committee, a copy of this Section of the Bylaws and the list of nominees recommended by the National and District Nominating Committees. The notice shall also state that no other names shall appear on the final election ballot unless proposed by at least one hundred (100) qualified Corporate Members. Such write-in or letter ballot nominations, if applying to District Directors or to District Representatives on the National Nominating Committee, shall be signed only by qualified voters within the District concerned, and there shall be not less than ten (10) ballots from each of the majority of the number of Sections represented in the District. If the write-in or letter ballot nominations apply to other offices, then the ballots shall include not less than ten (10) ballots from each of five (5) Sections.

(*c*) The nomination ballots must be placed in a plain envelope and sealed; then inserted in a second envelope and sealed. The voter shall then sign his name thereon in ink and mail it to the Secretary. The Secretary shall certify to the eligibility and signature of all voters returning endorsed nomination ballots and shall then deliver them unopened to the Tellers of Election. (See Section 8 of this Article.) A nomination ballot without autographic endorsement of the voter written on the outside envelope shall be considered defective and shall not be canvassed by the Tellers of Election. The Tellers shall first open and destroy the outer envelopes of all properly endorsed ballots, and shall then open the inner envelopes, canvass the ballots and certify the results to the Secretary. If no nominations, other than those proposed by the Nominating Committees, are made by endorsement of at least one hundred (100) qualified members as provided for above, then the Secretary shall treat the nomination ballots as Election Ballots and shall cast the ballot for the election of the candidates so nominated.

(*d*) Any vacancy in the list of nominees for offices in the SOCIETY due to the death, withdrawal or disqualification of a candidate, existing on November 1st or occurring after that date, shall be continued until after the election. Any resulting vacancy in the list of elected officers shall be filled in the manner prescribed in the Bylaws for filling the vacancy in the unexpired term of the office in question. (See Article III, Section 2 (*d*) and Article V, Section 3.)

Section 3. Election.

(*a*) If a member, not proposed by the Nominating Committee, is duly nominated as provided for in Section 2 of this Article, then the Secretary shall mail, on or before the 20th day of February of that year, to each member entitled to vote, a ballot stating the names of the candidates for the offices for which more than one candidate has been nominated, with a brief biographical sketch of each nominee (except nominees for the Nominating Committee), as prepared by the National Nominating Committee. The time for the closure of the voting shall also be stated. The ballot sheet shall list the names of the candidates proposed by the Nominating Committees and the respective offices for which they are candidates and the names of candidates nominated by letter ballot as provided for in Section 2, Paragraphs (*b*) and (*c*), of this Article. Candidates selected by the Nominating Committees shall be identified by an asterisk.

(*b*) The voter shall prepare his ballot by means of a cross or check mark placed opposite the name of each candidate for whom he wishes to vote. The voter shall enclose said ballot in plain envelope and seal same. He shall then enclose the sealed envelope in a second envelope marked "Ballot for Officers," seal same and sign his name thereon in ink for identification, and mail it to the Secretary. The Secretary shall certify to the eligibility and signature of all voters and shall then deliver them unopened to the Tellers of Election. (See Section 8 of this Article.)

A ballot without the autographic endorsement of the voter written on the outside envelope shall be considered defective and shall be rejected by the Tellers of Election. A ballot which has choice indicated for more names than there are offices to be filled shall be considered defective and shall be rejected by the Tellers.

Section 4. Closing Date for Election.

The voting for the election of officers shall close on the 20th day of March, unless this date falls upon a Sunday or a holiday, at which time the closing date will be the following day. The Tellers shall not receive any ballots after the stated time for the closure of the voting.

The Tellers of Election shall first open and destroy the outer envelopes and shall then open the inner envelopes, canvass the ballots and certify the results to the Secretary. The candidates having the greatest number of votes for their respective offices shall be considered elected.

Section 5. Tie Votes.

In case of a tie in the vote for any office, the President shall cast the deciding vote, except in such case where he is involved in a tie vote, then the Vice-President who is Chairman of the Administrative Council shall cast the deciding vote.

Section 6. Announcement of Election.

The names of the Elected Officers shall be published in the May issue of the WELDING JOURNAL.

Section 7. Date to Assume Office.

The term of all Elected Officers shall begin on June 1st. Officers shall continue in their respective offices until their successors have been elected and qualified.

Section 8. Tellers of Election.

The President shall, on or before the 1st day of January, appoint three (3) Tellers of Election whose duties shall be to canvass, on or before January 31st, the ballots cast for nominees; and when an election ballot is conducted, to canvass the election ballots, on or before March 25th, and shall certify the result, in each case, to the National Secretary. Their term of office shall expire when their report of the canvass has been presented and accepted.

ARTICLE VII
Meetings, Exhibits, Quorum and Fiscal Year

Section 1. Annual Meeting.

The Society shall hold an Annual Meeting each year (unless prevented by governmental restrictions), at such time and at such place as the Board of Directors may designate.

Section 2. Special Meetings.

Special meetings of the SOCIETY may be called at any time by the Board of Directors.

Section 3. Organization of Annual and National Meetings.

The SOCIETY's Convention Committee shall plan and make arrangements for and correlate activities in connection with Annual and National Meetings in cooperation with the Technical Papers, Publicity, Educational and Manufacturers Committees. In making local arrangements for the Annual or a National Meeting, the local Arrangements Committee shall be guided by an Outline of Procedure, furnished by the SOCIETY's Secretary. The SOCIETY's Secretary, in consultation with the Treasurer, and the Chairman of the Convention Committee, and Representative Members of the Technical Papers, Publicity, and Manufacturers Committees, shall prepare a budget and submit it to the Finance and Executive Committees for approval. A copy of this budget shall be submitted to each member of the SOCIETY's Convention Committee for guidance.

Section 4. Board of Directors.

Meetings of the Board of Directors shall be held at the call of the President, or at the written request of five (5) members of the Board.

Section 5. Notice of Meetings.

Notices of all National meetings of the SOCIETY shall be mailed to the members at least thirty (30) days prior to the date of such meeting. Notices of all Board of Directors meetings shall be mailed to the members of the Board at least two (2) weeks prior to the date of the meeting. Notices of all meetings of Standing Committees shall be mailed to members of the committee at least two (2) weeks prior to the date of the meeting. All meeting notices shall designate the time and place of the meeting and the principal business to come before it.

Section 6. Exhibits.

The SOCIETY may also, in connection with the Annual Meeting or otherwise, hold an Exhibit if the Board of Directors shall so determine. With the approval of the Board of Directors, the SOCIETY's Convention Committee, in cooperation with the Manufacturers Committee, shall carry on negotiations for the Exhibit. The approval of the Board of Directors must first be secured to all proposed agreements before committing the SOCIETY to participation.

Section 7. Quorum at Meetings.

Twenty (20) members, entitled to vote, shall constitute a quorum at meetings of the SOCIETY and ten (10) Directors shall constitute a quorum at meetings of the Board of Directors, and a majority of the Committee members shall constitute a quorum at meetings of Standing Committees. If, at a duly called meeting, a quorum is not present, those assembled may proceed with the specified agenda; however, all action taken shall

be submitted by letter ballot for confirmation, to the entire membership of the group or committee involved.

Section 8. Fiscal Year.

The Fiscal Year of the SOCIETY shall commence on June 1st and end May 31st.

ARTICLE VIII
Committees

Section 1. National Nominating Committee.

The National Nominating Committee shall consist of fifteen members made up of a Chairman, eleven elected District Representatives and three Members-at-Large. The Chairman shall be appointed by the President and should preferably be the immediate Past-President of the SOCIETY. If the immediate Past-President is not appointed as Chairman, he shall be appointed a Member-at-Large. The Chairman may, however, be appointed from among any of the Past-Presidents or the Past Members of the Executive and Finance Committee. The Chairman shall not serve for more than one year continuously as Chairman. Immediately following his term as Chairman, he shall serve a one-year term as Member-at-Large on this Committee, if available. The eleven District Representatives shall be elected from their respective Districts in accordance with provisions set forth elsewhere in these Bylaws. Two Members-at-Large shall be appointed by the President from among those who hold or have previously held office on the Board of Directors or have served as Chairman, Vice-Chairman, or Secretary of a National Standing, Technical or Special Committee. The third Member-at-Large shall be the Chairman of the previous year's National Nominating Committee, if available. No member of this Committee, other than the Chairman who serves in the pattern described above in this section, shall serve for more than one year continuously. At all times at least one Past-President shall be a member of this Committee. Announcement of the personnel of the Committee shall be made through publication in the August issue of the WELDING JOURNAL.

It is the duty of this Committee to nominate candidates for National elective office. The Committee shall hold an open meeting preferably at the time and place of the Annual or a National Meeting at which time members may appear to present and discuss the eligibility of candidates for the various offices falling vacant. The Committee shall deliver to the National Secretary, in writing, on or before the first day of November of that year, the names of its nominees for the various elective offices next falling vacant, with the written acceptance of each nominee. (Nominees for District Director and for District Representative on the National Nominating Committee shall be nominated by each District Nominating Committee. See Article III, Section 2 (*c*). The nominees for Directors-at-Large shall be selected by the Nominating Committee with due consideration to geographical distribution. The Committee shall also prepare a brief biographical sketch of each nominee (except for the Nominees for the District Representatives on the National Nominating Committee and for the District Directors), which shall be submitted to the National Secretary for publication in the WELDING JOURNAL and in the case of an election ballot it shall be submitted to the membership with the election ballots. The biographical sketches shall cover nominees selected by the National Nominating Committee, the District Nominating Committees and those nominated by petition of the membership in accordance with Article VI, Section 2 (*b*) and 2 (*c*).

Section 2. Office Assignment Committee.

The Office Assignment Committee shall consist of either five or six members made up of the Chairman of the National Nominating Committee as Chairman, the current Chairmen of the four Functional Councils; that is, the three current Vice Presidents, and the Past President serving as Chairman of the Administrative Council (who may also be Chairman of the National Nominating Committee) and the President-elect. It shall be the duty of the Committee to recommend to the President-elect and to the incoming Board of Directors the assignments of individuals to the Executive and Finance Committee of the Board and to the Functional Councils. Following the polling of member ballots by the tellers of election, this Committee shall carefully screen the qualifications, past, professional, technical, or business experience, and known or indicated interests of each of the elected Vice Presidents, Directors-at-Large, and District Directors, and shall make the recommendation of assignment in accordance with their considered judgment. They shall report to the President-elect not later than April 1st.

Section 3. Constitution and Bylaws Committee.

The Constitution and Bylaws Committee shall consist of three members, each to serve for a period of three years, one member of which shall retire each year. The Chairman of the Committee shall be designated by the President. It shall be the duty of this Committee to present and to receive suggestions for revisions to the Constitution or Bylaws and to be responsible for the preliminary wording of such revisions. It shall see that the Bylaws of Sections and Student Chapters of the SOCIETY shall not conflict with any provision of the Constitution and Bylaws of the AMERICAN WELDING SOCIETY. This Committee shall consider and report upon any petition for revision to the Constitution or the Bylaws and shall transmit such petition to the Secretary for further consideration as specified in Article VI of the Constitution and Article XII of the Bylaws. The Committee, through its Chairman, shall report its actions and recommendations to the Administrative Council.

Section 4. Technical Activities Committee.

The Technical Activities Committee shall consist of a Chairman, a Vice Chairman, the Technical Secretary who shall serve as Secretary, the Chairmen of all the Technical Committees of the SOCIETY and three additional members, each to serve for a period of three years, one member of which shall retire each year, and, *ex officio*, the Chairman of the Public Relations Committee. The Chairman and Vice Chairman shall be appointed by the President on recommendations by the TAC and the Technical Council and shall serve for a period of three years.

The Executive Subcommittee of the Technical Activities Committee shall be comprised of the Chairman, Vice Chairman and Secretary of the Technical Activities Committee, with not more than six additional members appointed annually by the Chairman. It shall be the function of this Executive Subcommittee to act for the Technical Activities Committee in the time between meetings of the full Committee and as otherwise requested by the Chairman. All actions of the Executive Subcommittee shall be submitted to the full membership of the Technical Activities Committee and such actions shall be considered as final unless objection has been received from a member of the Technical Activities Committee within two weeks of the date of mailing of minutes or other communication advising of such action.

The scope of this Committee shall be: to organize and administer the activities of the Technical Committees of the SOCIETY in accordance with the "Rules to Govern Organization, Functions and Operations of Technical Committees of the AMERICAN WELDING SOCIETY," said rules to be of latest revision as approved by the Board of Directors; to nominate and administer the activities of official representatives of the SOCIETY on Technical Committees of other Societies in accordance with the "Guide for the Appointment and Functioning of Representatives of the AMERICAN WELDING SOCIETY on Technical Committees of other Societies," as approved by the Board of Directors; to promote the standards of the SOCIETY through the AWS Technical Committees and AWS Representatives on Technical Committees of other Societies; to act in an advisory capacity to the Technical Council in respect to technical matters; to collaborate in the preparation and review of technical regulatory requirements of governmental and other code-writing bodies and to cooperate with these bodies in any other reasonable manner toward the elimination of unnecessarily restrictive welding requirements through the promotion of the SOCIETY's standards; by direct action jointly with the Public Relations Committee or by recommendation to the Technical Council, to participate in public relations matters of a technical nature affecting the interest of the members of the AMERICAN WELDING SOCIETY; to promote the technical advancement of welding through any other means as may appear proper to the Technical Council to insure the best interest of the art and science of welding.

The Committee, through its Chairman, shall report its actions and recommendations to the Technical Council.

Section 5. Technical Committees.

Technical Committees not limited in number, shall be established and shall operate in accordance with the latest revision of "Rules to Govern Organization, Function and Operation of Technical Committees of the AMERICAN WELDING SOCIETY," as approved by the Board of Directors, under the jurisdiction of the Technical Activities Committee.

Section 6. Standing and Special Committees.

Standing and Special Committees not limited in number may be created by the Board of Directors and members appointed thereto by the President with the approval of the Board of Directors. When such committees are created, the Board shall also create a set of operating rules which shall cover the scope and limitations governing the committee, the number of members, terms of membership and method of selection of members. The rules shall also state the Council to which the Committee shall report.

It shall be the responsibility of each committee to work within the rules established by the Board of Directors and to suggest from time to time changes or modifications in the rules which will increase the committee's effectiveness. All suggested changes must, however, be approved by the Board of Directors and issued as a new or revised set of rules before the Committee can act under such changes.

Standing Committees shall be established or discontinued only upon the approval of $^2/_3$ vote of the Board of Directors by letter ballot. The operating rules for Standing Committees shall also require approval by $^2/_3$ vote of the Board of Directors by letter ballot.

Special Committees may be created by majority vote of the Board of Directors present in session or by letter ballot for a definitely stated purpose or purposes. Such committees shall continue to function until their purpose has been accomplished or until discharged by the Board of Directors.

ARTICLE IX
Awards, Publications and Research

Section 1. Awards.

Awards, prizes and certificates may be established by the SOCIETY or by Associations, Firms or Individuals and administered by the SOCIETY subject to the approval of the Board of Directors. All awards, prizes and certificates shall be administered in accordance with rules established by the Board of Directors.

Section 2. Publications.

(*a*) *The* WELDING JOURNAL. The SOCIETY shall publish a magazine to be known as the WELDING JOURNAL of the AMERICAN WELDING SOCIETY. It shall contain technical papers, WELDING SOCIETY news, and information of interest to the members of the AMERICAN WELDING SOCIETY. The WELDING JOURNAL shall be sent to each member of the SOCIETY in good standing, except those whose dues have been exempted in accordance with Article II, Section 1 (*d*).

(*b*) *Codes and Specifications.* The SOCIETY retains the right or privilege of publishing as an AMERICAN WELDING SOCIETY Standard any Code, Specification or Standard prepared by its committees or by its committees working jointly or in cooperation with another SOCIETY or other Societies, Association or Regulatory Body.

(*c*) *Other Publications.* Other publications which promote the objects of the SOCIETY as set forth in its Constitution may be issued at the discretion of the Board of Directors.

(*d*) *Copyright and Responsibility for Statements.* The SOCIETY retains the right to copyright any of its papers, discussions, reports or publications. The SOCIETY shall not be responsible for statements or opinions advanced in papers or in discussion at meetings of the SOCIETY, of its Sections or Districts, or printed in its publications.

(*e*) *Use of* SOCIETY *Name or Emblem.* Unless approved by the Board of Directors, the name, emblem or initials of the SOCIETY shall not be used in any commercial publications or business, except to indicate individual membership in the SOCIETY or conformity with its standards, or recommended practices.

Section 3. Welding Research.

The AMERICAN WELDING SOCIETY shall provide for research in welding and the related processes as a SOCIETY and/or by cooperating with the separate research organization known as the Welding Research Council. A separate section of the WELDING JOURNAL of the AMERICAN WELDING SOCIETY may be provided for the publications of the Welding Research Council.

Research funds of the SOCIETY may be obtained through voluntary or solicited contributions and/or by appropriation from the regular funds of the SOCIETY. Solicitation of funds in the name of the SOCIETY may be made only with the approval of the Board of Directors. The Treasurer of the SOCIETY shall be the Custodian of research funds.

ARTICLE X
Voting and Proxy

Section 1. Voting.

Each Corporate Member as described in Article 1, Section 1 (b), shall be entitled to vote on all questions presented by the SOCIETY or by the Section to which the member belongs.

Section 2. Voting by Proxy.

Voting by proxy shall be permitted at any meeting of the SOCIETY, or of its Board of Directors, or in any of its Committees, by personal representative consisting of a member of the particular group or committee, presenting written credentials at the stated meeting, and covering only those matters clearly stated on the face of the proxy. All proxies must be in writing and must be delivered to the Secretary of the meeting at which they are to be voted, prior to the opening hour of the meeting.

Section 3. Voting by Mail.

Voting by mail shall be used for the election of officers. It may also be used to ratify action taken at a duly called meeting when a quorum is not present, and also by Committees when it is not expedient to convene the Committee.

ARTICLE XI
Parliamentary Rules

Section 1.

Roberts' "Rules of Order" shall be the governing parliamentary law of the SOCIETY in all cases not definitely provided for by its Constitution or its Bylaws or its own rules.

ARTICLE XII

Section 1. Amendments.

Amendments to these Bylaws may be instigated by filing with the Secretary a petition containing a copy of the proposed amendment signed by not less than ten Corporate members in good standing or by the Constitution and Bylaws Committee or by the Board of Directors. Such proposed amendments must be in conformity with the Constitution and to become effective must thereafter be approved by not less than two-thirds of the Directors present at a meeting regularly called for that purpose, a quorum being present, provided that a written notice of such proposed amendments shall have been given at a previous meeting of the Board and provided further that the Secretary shall have mailed a copy of such proposed amendments to each member of the Board at least sixty days in advance of the meeting at which action thereon is to be taken. If approved by the Board of Directors, the amendments shall be considered temporary and then shall be published in the WELDING JOURNAL and within not less than thirty days a letter ballot shall be submitted to the membership on said amendments as so published in the WELDING JOURNAL. Such amendments shall be deemed adopted at the expiration of sixty days after the mailing of the letter ballot unless rejected by the votes of at least twenty percent of the corporate membership eligible to vote or by at least fifty-one percent of the total votes actually cast and delivered to the Secretary within sixty days of the date of mailing of the letter ballot.

AWS DIRECTORS-AT-LARGE

Term Expires	1959	1960	1961
	J. H. Blankenbuehler	J. F. Deffenbaugh	A. A. Holzbaur
	G. E. Linnert	A. E. Pearson	D. B. Howard
	P. G. Parks	C. M. Styer	C. E. Jackson
	F. H. Stevenson	R. M. Wilson, Jr.	J. L. York

AWS DISTRICT DIRECTORS

District No. 1•New England	Sidney Low	District No. 6•Central	J. N. Alcock
District No. 2•Middle Eastern	E. E. Goehringer	District No. 7•West Central	A. F. Chouinard
District No. 3•North Central	H. E. Miller	District No. 8•Midwest	F. G. Singleton
District No. 4•Southeast	E. C. Miller	District No. 9•Southwest	P. V. Pennybacker
District No. 5•East Central	H. E. Schultz	District No. 10•Western	F. V. McGinley
		District No. 11•Northwest	C. B. Robinson

OTHER DIRECTORS

Junior Past-President	J. H. Humberstone	Junior Past-President	C. P. Sander
Junior Past-President	J. J. Chyle		

JOIN AWS...

. . . and help build yourself a better future through a stronger and more prosperous welding industry. Grow with the industry and progress with AWS.

Your membership brings you these advantages:

- Welding Journal—The World's outstanding welding engineering and application magazine comes to you each month.
- Welding Handbook—The "Bible" of the welding industry—Full Members receive a new 500 page section each year.
- Section Activities—Each month you join other Section Members in meetings, plant tours, educational courses, social and recreational activities: greeting the experts, interchanging ideas, learning new welding know-how, enjoying fellowship and having good fun.
- National Activities—Annual Meetings, the Welding Exposition, more than one hundred technical and operating committees provide opportunities for your national participation.
- Welding Standards—You can help develop the manuals, codes and specifications used nationally and internationally to control welding and welded fabrication.

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AMERICAN WELDING SOCIETY, INC.

33 WEST 39th STREET • NEW YORK 18, N. Y.

KEEPING YOU POSTED

by Fred L Plummer

● Late February visitors at SOCIETY headquarters included Amel Meyer and O. T. Barnett of Chicago on successive days, and Ross Whitehead of *Steel* magazine who was preparing a major review article covering new developments in welding processes and equipment. *Business Week* of February 21st carried an interesting article describing welded fabrication by the R. C. Mahon Co. and referring to Director-elect Ray Stitt.

● On March 2nd President G. O. Hoglund and your Secretary began a three-week tour which included visits with eleven sections, and attendance at the IAA convention in New Orleans and the Western Metal Congress and Exposition in Los Angeles.

● Landing in Nashville your Secretary was greeted by a large delegation led by President Hoglund, who had arrived on an earlier flight, Past-director J. U. Durham, Chairman J. E. Bevill and Russell Staub. A TV crew was on hand to film the occasion and record interviews with President Hoglund and your Secretary. These were broadcast as part of the evening news report on Channel 5. Following afternoon visits with local firms interested in welding, the evening social period, dinner and technical meeting were held at Highland Crest Restaurant with a large group in attendance. Your Secretary presented the technical talk covering construction of storage and process vessels after President Hoglund discussed SOCIETY plans and activities. Section Officers Belew, Brach, Durham, McCann, Moran and Welch assisted Bevill and Staub in handling a very successful meeting of this recently activated section.

● Returning to our hotel late that night your Secretary found a message requesting a telephone call. This came from a former Case student, J. Figilis, as a result of the TV broadcast and led to an early breakfast and inspection of a large building project which included unusually heavy welded steel trusses which had been fabricated and erected by Ingalls Iron Works.

● A pleasant flight carried us to Birmingham airport where we were met by R. A. Davis who was host during a short visit at his home and a tour of the Chicago Bridge and Iron Co. plant. At the request of E. K. Carlson, President Hoglund agreed to prepare an editorial for the April issue of *Alabama Engineer* promoting Welded Products Month. With Chairman E. H. Turnock in Canada, Vice-chairman Davis presided at the dinner meeting at which your Secretary discussed SOCIETY activities and President Hoglund gave a technical talk covering the use and welding of the newer high-strength aluminum alloys. Secretary Nickell, Past-chairman G. P. Black and E. K. Carlson assisted during the meeting. Director Al Pearson was host at an after-meeting session held at the Club on Iron Mountain which provides a fine night view of the city.

● The next morning an early flight delivered us at Mobile airport about 9:00 A.M. where we rented a car and enjoyed an early display of azaleas on our drive into Mobile to join Leo Veal and W. F. Weldon for a luncheon discussion of the work of the activation committee for a Mobile Section. Others active on this project include W. A. Pierre, T. Taul, J. Dunn and H. Fahnert.

● Following luncheon we drove to Pascagoula with a short stop to visit Bellingroth Gardens where we saw an unusually large collection of camelias. At Longfellow House we were welcomed by Ingalls Ship President Mayo and several of his associates. Section Chairman E. M. Anderson, assisted by Officers Dumont, Holder, Lamb, Pierre and Slaughter, conducted the dinner meeting at which President Hoglund gave the technical talk and your Secretary spoke about SOCIETY activities.

● Rain and high winds accompanied us the following day as we drove from Pascagoula to the Mobile airport. We then endured a much delayed and very rough flight to Atlanta where we missed our connecting flight, but had lunch and caught a later and equally rough flight which finally brought us to Chattanooga some three hours behind schedule. We were greeted by John Dixon and driven to our hotel without time for the anticipated visit at the plant of Combustion Engineering. Chairman W. B. Bunn, with Officers H. J. Korner, J. H. Mesich and John Dixon, conducted the meeting which filled a large dining room with many guests including Russell Staub from Nashville, and Chairman Hugh Harr and others from the Holston Valley Section. President Hoglund discussed SOCIETY affairs this evening and your Secretary gave the technical talk.

● The next morning a short airplane flight and a long limousine ride took us to Knoxville and on to Oak Ridge National Laboratory where we lunched with Director E. C. Miller, Section Officers T. C. Swindell, C. H. Wodtke, H. M. Payne and others, and then enjoyed a tour of the laboratories and various atomic reactors. At the dinner meeting of the Northeast Tennessee Section all six Past Chairmen were present to hear President Hoglund discuss the welding of aluminum alloys and learn of SOCIETY plans from your Secretary.

● Next stop was New Orleans where Alcoa representative Murray Crawford provided cordial southern hospitality, including a Sunday boat trip on Lake Pontchartrain. Monday morning the 61st anniversary convention of the International Acetylene Association opened at The Roosevelt Hotel. President Hoglund and your Secretary joined AWS Section Officers J. A. Wilson, W. G. Blackwell, G. G. Haddock and S. L. Ritter at lunch for a discussion of local AWS activities. During the evening, with President H. S. Sutherland presiding, IAA held a reception and dinner at which the Morehead Medal was presented to S. B. Kirk by C. E. Monlux, following short addresses by C. J. Haines, A. B. Kinzel and E. Easterly. President Hoglund and your Secre-

tary were seated with Officers and Past Presidents of IAA including R. B. Swope, L. W. Mench, C. M. Pitts, R. H. Dieckelman, and the charming wife of President-elect L. L. McBurney. IAA Secretary L. G. Matthews was in charge of arrangements.

● Panelists at the Tuesday session on Safety and Safe Practices included AWS Vice-president-elect A. F. Chouinard and active committee member F. C. Saacke. AWS Public Relations Chairman H. R. Morrison was Moderator for this successful meeting at which the new NBFU leaflet "Sparks Astray" (AWS cooperated in preparation) was distributed.

● At Baton Rouge James N. Shilstone was host and, in cooperation with Director Jack York and Chairman H. R. Klug, provided a full schedule of activities which included inspections of Delta Tank where Director York explained welding activities, the 384-ft diam geodesic-dome shop of Union Tank Car Co., a synthetic plant of W. R. Grace and Co. (Lewis Spann was host), the pipe-fabricating facilities of Cal-Metal Pipe Corp. where Manager R. C. Stewart described new high-frequency equipment now being installed, and a night view from the Mississippi River bridge of the "horizontal Christmas tree"—the thousands of lights of the brilliantly lighted metal, petroleum and chemical plants which make up the fabulous industrial and port area of Baton Rouge.

● At the dinner meeting of the Section, President Hoglund presented the technical talk and your Secretary discussed SOCIETY activities after joining Claude Elbourne in judging welding projects developed by high-school students with section members acting as advisors. Several excellent projects had been developed and the judges had difficulty in selecting the winner—a motorized model of a circumferential and longitudinal welding machine for shop-fabricated tanks, constructed by Vernon Akers, with Director Jack York as advisor. This project will be exhibited at the Chicago Welding Exposition and winner Akers and one of his parents will travel to Chicago with Jim Shilstone as guests of the Baton Rouge Section during the AWS Annual Meeting and Welding Exposition. Wives and mothers attended this outstanding meeting at which Paul Wamsley and D. L. Sprow assisted Shilstone and Klug. Mrs. Herman Nelson pinned lovely camelias, developed by her husband, on President Hoglund and your Secretary.

● Director-elect Cliff Moss and Secretary Edward Mai were waiting in the Dallas airport when we completed the trip from Baton Rouge with a change at Shreveport. Activities included a luncheon with hotel and convention bureau representatives in the City Club, inspections and a brief visit at the home of Cliff Moss prior to the evening section meeting at Amon Carter Field, conveniently located for both Dallas and Forth Worth members. Included in the large crowd, in addition to Moss and Mai, were Director Percy Pennybacker, Section Officers Al Bernson, J. C. Collins, Jim Bland, George Werner, and long-time AWS member L. Welch. Your Secretary discussed AWS activities and then left for the west coast while President Hoglund was giving the technical talk.

● The Los Angeles Section sponsored the "Kick-off Luncheon" which helped open the Western Metal Congress and Exposition on Monday, March 16th. Chairman John B. Ross presided as Past-president C. P. Sander introduced President Hoglund who spoke briefly. Director F. McGinley, Director-elect C. Smith, your Secretary and Section Officers R. C. Hayes, A. M. Thompson, L. West, R. J. Frick and D. P. O'Connor were also seated at the speakers' table. Seven technical sessions devoted to welding were planned and conducted by the Los Angeles Section. Many papers were devoted to problems involved in the construction of aircraft, rockets and missiles. Session chairmen included Director F. Stevenson, Prof. R. C. Wiley and R. C. Hayes. Social events included the ASM dinner dance held at Moulin Rouge, a luncheon in the Cocoanut Grove, Ambassador Hotel, at which Prof. R. McMasters was master of ceremonies, and a delightful evening with Past-president and Mrs. Sander.

● Officers of the Los Angeles Section met with President Hoglund and your Secretary on Friday afternoon. Several of these men then drove to Long Beach for a dinner meeting of that section at which President Hoglund spoke on the welding of aluminum alloys and your Secretary again described activities of the AWS.

● A District Meritorious Certificate Award was presented to O. B. Bowers by President Hoglund. Past-president Sander, Past-director Breese, Director McGinley, Director-elect C. Smith, Los Angeles Chairman Ross and Chairman-elect Hayes, and a delegation from San Diego including R. L. Hawkins joined with Long Beach Officers McClure, Hogate, DeRouchey, McGowan, Teeter, Butler, Schuyler, Walling and Garfield in this well-attended meeting.

● The following morning President Hoglund left Los Angeles on a flight to Pittsburgh to conclude this successful series of visits with AWS Sections. Both he and your Secretary wish to extend best wishes and deepest appreciation to the very large group of men who made these visits so enjoyable and profitable—"AWS Men of Welding are tops in hospitality."

● These notes are being finished on a jet 707 flying nonstop from Los Angeles to New York where we are scheduled to arrive at 7:00 A. M. Sunday, March 22nd. On this trip we have traveled at ground speeds varying from perhaps $^1/_2$ mile per min in a rain and wind buffeted auto up through those of DC3s, Convairs, Constellations, DC6 and 7s and an Electra to our present speed of about *10* miles per min.

Plan Now to Attend
1959 AWS National
Fall Meeting
Sept. 29–Oct. 1, 1959
Detroit, Mich.

Welcome

• Supporting Companies

Effective April 1, 1959:

Columbia Gas System Service Corp.,
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Columbus 12, Ohio.

Robert Holmes & Brothers, Inc.,
510 Junction Ave.,
Danville, Ill.

TECHNICAL PROGRESS

Automotive Committee Selects Six Papers for Detroit Meeting

At the recent meeting of the AWS Technical Papers Committee in New York, final selection was made of the technical papers to be presented at the AWS National Fall Meeting to be held this Fall in Detroit. Since Detroit is the center of the automobile industry, it was considered desirable to set aside two sessions for papers on automotive welding.

The following week, the AWS Automotive Welding Committee met at the Willys Motor Plant in Toledo where 13 papers were presented to the Committee for possible use for the forthcoming Fall Meeting. Six papers were chosen for the two sessions, and one additional paper was selected as an alternate. All of the papers deal with such recent developments in automotive welding as integral-frame construction, automation methods and design for welding.

Welding Manual Discussed for Automotive Designers

The Committee also discussed preparation of a welding manual for automotive designers. Various sections of the manual were reviewed and many suggestions were incorporated. The first complete draft of the manual is expected to be assembled within a few months, and a review by the Committee of the entire book will be scheduled shortly thereafter.

Automotive Committee Tours Willys Plant

Many interesting welding processes were revealed in the Committee's plant tour of Willys Motors. Of particular interest among the various phases of production of "Jeep" vehicles was a new one, the "Mule," now in production for the Army. Consisting basically of a horizontal platform mounted on four wheels, it is designed to carry either personnel or cargo. Composed almost entirely of aluminum and magnesium, including an aluminum engine and a magnesium body, the vehicle weighs some 700 lb.

Tests Evaluated for Welding of Cast Iron

The AWS-AFS Committee on Welding Iron Castings convened at the Detroit plant of the Cadillac Motor Car Division of General Motors. Under consideration were a review and evaluation of data from a large series of tests.

During the past few years, this Committee has been conducting a test program with the aim of finding the best way presently known to weld cast iron. In the current series of tests, each of 14 companies used the same welding procedure in an effort to see if the results obtained were reproducible. Specimens of gray, nodular and malleable cast iron were welded by the arc- and gas-welding processes using ENiFe electrodes, RCI welding rods and a proprietary cerium-bearing cast-iron welding rod.

After a detailed examination of the test data, it was agreed to undertake a statistical correlation of the results. An attempt will be made to correlate results of the radiographic, penetrant-oil and mechanical tests performed on the specimens. In addition, three preliminary reports will be prepared on what to expect when welding gray, nodular and malleable iron.

Part of this meeting was also spent in a tour of the Cadillac plant with particular emphasis on their foundry and welding operations.

Publication Completed on Nuclear Piping

The AWS Committee on Piping and Tubing has completed the first national publication dealing with the welding of nuclear piping.

The application to nuclear service of materials now used for pressure piping in nonradioactive service has raised the question of what changes are necessary in welding procedures because of these new service environments. The new AWS report indicates what these changes are. It contains diagrams showing specific joints details as well as information on electrodes, cleanliness and inspection. Copies of this new publication will be available shortly.

Welding Standard Proposed for Nuclear Reactors

Recently, the American Nuclear Society has been collecting and reviewing the welding specifications presently used in the fabrication of nuclear reactors and piping systems. As a result, they have prepared a preliminary report on Welding Standards which is currently being reviewed by the AWS Committee on Piping and Tubing.

It is expected that this procedure will eventually lead to one uniform set of welding standards in the nuclear field.

AUTOMOTIVE COMMITTEE MEETS AT THE WILLYS PLANT

Shown at the recent meeting in Toledo of the AWS Automotive Welding Committee are (left to right, seated): G. L. Zastrow, E. A. Fenton, J. E. Fitzwater, C. R. Lenox, W. J. Evans, W. H. Mitsch and W. G. Morgan. Standing (left to right) are J. P. Koss, R. S. Phair, W. Kroy, J. Cruchet, W. F. Chase, T. W. Shearer, Jr., J. R. Wirt, H. R. Sparks, Z. J. Fabrykowski and T. F. Ellis

EDUCATIONAL ACTIVITIES

Comprehensive Welding Course in Progress at the University of Michigan

The Extension Service Department of the University of Michigan has introduced a noncredit course held in the welding laboratory of the school's Mechanical Engineering Department. The course, covering both the practical and theoretical aspects of welding, is extremely flexible and can be equally valuable to those who wish to improve their technical knowledge and those who are interested primarily in manipulative skill or in the use of a new welding process. Those with little or no knowledge of welding can learn the fundamentals and obtain practical training.

The University Extension Service publication describes this course in electric welding as being designed to meet the needs of two groups: (1) those interested in qualifying for welding certification in all four positions of arc welding and (2) those interested not only in practical welding but also in technical phases such as welding metallurgy, physical testing and inspection of welds, study of electrode materials and applications, theory of arc welding, use of oxygen-cutting equipment, hard surfacing by the electric arc, designing for welding, welding costs and AWS welding symbols. Also, practical training in gas-shielded metal-arc welding and atomic-hydrogen arc welding is provided. Each class is limited to 15 students, with a 3-hr session every Monday evening for 16 weeks.

A questionnaire is given each member of the class at the opening session to ascertain his personal welding interests. A specific program is then formulated for him. This procedure helps the entire class to get off to an early start on its program. A typical questionnaire covers the following points:

A one-hour lecture is given at each class session covering technical interests indicated on the completed questionnaires returned by the students. This is followed by a practical demonstration for the entire class. The remaining time is devoted to laboratory work under close supervision by the instructor. Each student has his own welding booth—provided with a downdraft suction system for proper ventilation.

Adult Education

Name_____ Yrs. of experience in welding_____
Company_____ City_____

Course Coverage

I. Group A. Qualifying in welding
- (*a*) Qualifying for welding certification
  1. AWS welder's certification test
  2. Other welding certification

II. Group B. Practical welding
- (*a*) Practical arc welding—Beginners—Advanced
- (*b*) Practical atomic-hydrogen arc welding
- (*c*) Practical inert-gas metal-arc welding

III. Group C. Technical phases of welding
- (*a*) Theory of arc welding
- (*b*) Welding symbols
- (*c*) Design for welding
- (*d*) Welding metallurgy
- (*e*) Testing of welds
  Destructive–Nondestructive
- (*f*) Inspection of welds
- (*g*) Electrode materials
- (*h*) Oxygen cutting
- (*i*) Hard surfacing
- (*j*) Welding costs

IV. Group D. Your suggestions

The class is taught how to determine physical test data such as yield strength, tensile strength, percent of elongation and percent of reduction of area. Various problems of successful weldments and weld failures are analyzed. The grain structure of weld failures is studied by means of microscopes.

The problem of ascertaining the specific welding interests of a group of students and the establishment of a program which will satisfy their needs has been solved at the University of Michigan by this questionnaire approach. The system entails much individual attention, but with small, compact groups each student gains by the diversified instruction he desires. Each student advances at his own pace. His individual progress is not affected by the remainder of the class.

Section 2 of Welding Handbook Still Available

Copies of the Welding Handbook, Fourth Edition, Section 2, are still available. This particular section is devoted to gas, arc and resistance-welding processes. Over 500 pages in length, the volume is illustrated with photographs, graphs and symbols.

Copies may be obtained from the AMERICAN WELDING SOCIETY, 33 W. 39th St., New York 18, N. Y., at a list price of $9.00 per volume.

WELDING COURSE AT UNIVERSITY OF MICHIGAN STRESSES INDIVIDUAL INSTRUCTION

The instructor demonstrates the starting of a $^3/_8$-in. AWS welder qualification test plate in the flat position

A few of the class watch a demonstration of mechanical testing of a $^3/_8$-in. AWS tensile-test coupon on a 60,000-lb tensile-testing machine

The class makes preliminary preparations before working on their arc-welding machines in the laboratory

Other class members study grain structure of welds by means of microscopes

EAC TOURS OHIO STATE'S WELDING LABORATORY

The AWS Educational Activities Committee met at the Department of Welding Engineering, Ohio State University, on Feb. 11, 1959. Professor Roy B. McCauley is seen on the left describing the operations of his equipment. Left to right (back row) Roy B. McCauley, Irving G. Betz, Robert G. Nottenburg, Merle E. Strong, Clarence E. Jackson, Stanley T. Walter, Arthur L. Phillips, T. Embury Jones, Howard B. Cary, Ralph W. Minga and Howard K. Hogan. In the foreground (left to right) are W. G. Leaman and H. A. Sosnin

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33 West 39 Street
New York 18, N. Y.

SECTION NEWS AND EVENTS

As Reported to Catherine M. O'Leary

Alabama

WELDING ALUMINUM ALLOYS

Birmingham—Eighty - five members and guests of the *Birmingham* Section met on the first Tuesday, March 3rd, to hear an excellent talk, "The Welding of Aluminum Alloys," as given by National President G. O. Hoglund.

The introduction of high-strength nonheat-treatable aluminum alloys by the materials manufacturer and inert-gas arc-welding equipment by the machine manufacturer has resulted in the application of welded aluminum construction for many new applications. Bridges, cranes, truck bodies, plus the usual use of aluminum for chemical lines and tanks are some of these applications.

The mechanical properties of welds in the aluminum-magnesium and aluminum-manganese alloys; static, fatigue, hydrostatic and other performance factors were the subjects of this discussion. Also included were typical examples of modern welded construction.

Coffee speaker was National Secretary Fred L. Plummer who gave a brief but interesting talk on the activities and future plans of the AMERICAN WELDING SOCIETY.

SECTION MEETING CALENDAR

JUNE 1

SAN ANTONIO Section. Plant Tour. Pak-Mor Mfg. Co., San Antonio, 6:30 P.M. Dinner 8:00 P.M. Cap't. Jim's.

JUNE 5

STARK CENTRAL Section. Golf Stag. Elms Country Club.

JUNE 6

CHICAGO Section. Annual Golf Outing. Southmoor Country Club, Orland Park, Ill.

JUNE 7

NEW ORLEANS Section. Annual Picnic.

JUNE 16

DAYTON Section. Annual Picnic. Inland Activities Center.

JUNE 20

OLEAN-BRADFORD Section. The Castle, Olean, N. Y. Dinner 7:00 P.M. Ladies Night-Dinner Dance—Election of Officers. Dancing 9:00 P.M. to 1:00 A.M. Music by Joe Prevesk.

Editor's Note: Notices for August 1959 meetings must reach JOURNAL office prior to May 20 so that they may be published in July Calendar. Give full information concerning time, place, topic and speaker for each meeting.

California

EDUCATIONAL LECTURE SERIES

Los Angeles—In its continued effort to help meet the ever-growing demand for men with the educational background to qualify as engineers and technicians in the welding industry, the *Los Angeles* Section, recently added, as another attraction, a series of educational lectures in fusion welding of a highly attractive and diversified nature. The lecture series was well conducted with between 50 to 60 in attendance at each lecture.

The first lecture was presented on January 27th by Dr. Alan E. Flanigan, professor of engineering, University of California at Los Angeles, whose subject was "Introduction to

BIRMINGHAM SECTION ADDRESSED BY NATIONAL PRESIDENT AND SECRETARY

President G. O. Hoglund discussed the welding of aluminum alloys with members of the Birmingham Section at March 3rd meeting. Picture shows (left to right) National Secretary Fred L. Plummer, Section Secretary K. V. Nickell, Director A. E. Pearson, President Hoglund, Vice-chairman R. A. Davis and Past-chairman G. P. Black

Mr. Davis presents to President Hoglund a check covering contribution of Birmingham Section to the new United Engineering Center Fund, in support of this important project

AMONG PRINCIPAL SPEAKERS AT LECTURE SERIES

The Los Angeles Section's first educational lecture series began on January 27th and ran through to February 12th. It dealt with various phases of fusion welding. Among the speakers were, left to right, above: A. P. Maradudin, F. Harkins, F. Drahos and Past President "Sandy" Sander. Section Chairman John Ross is shown, below, addressing some of the participants

INTEGRATED CORE PANELS DISCUSSED IN LOS ANGELES

Alan Glasser spoke on integrated core panels at the February 19th meeting of the Los Angeles Section. Here he is shown, at left, being congratulated by Howard Eubanks

Among the prominent guests in attendance at the meeting was Bergmann Franke Oberhausen, German welding engineer on tour of the United States

Members and guests present at the meeting show intense interest in the topic being covered by the speaker

Welding Metallurgy" which covered the importance of obtaining crack-free conditions in structural welds, thermal and mechanical treatments which accompany welding and the factors which control the rate of cooling after welding. The lecture was well supported by slides and the participation by the attendance during the discussion period was of great interest.

The rest of the lectures were as follows:

January 29th—Chet Shira, supervisor of Materials and Processes Section, Production Development Laboratory, Rocketdyne, whose subject was "Coated Electrode and Submerged-Arc Welding."

February 3rd—"Effects of Defects in Welds" was the subject presented by Alexei P. Maradudin, materials engineer and metallurgist for the Standard Oil Co., El Segundo, Calif. With the use of poloroid light and plastic coupons, Mr. Maradudin showed the various types of stress that occur in welded joints.

February 5th—Frank Harkins, chief welding engineer for Solar Aircraft Co., whose subject was "Welding Stainless and Low-Alloy Steels." The subject was well presented and followed by considerable discussion.

February 10th—The fifth lecture of the series was presented by Frank Drahos, senior metallurgist, Byron Jackson Division, Borg Warner Corp. His subject was "Welding for Nuclear Pumping Applications." Mr. Drahos has long been connected with the metallurgical and fabrication facets for nuclear pumps for most of the major nuclear plants and/or laboratories (governmental and private) in the United States. The lecture was of extreme interest.

February 11th—The sixth lecture of the series was presented by Robert E. Fish, research engineer for Rocketdyne. Mr. Fish's subject for the lecture was "Welding of Dissimilar Metals" which was well presented and well supported by the use of slides.

February 17th—The concluding lecture was presented by Sam E. Hickman, Rheem Manufacturing Co.

In view of the success of the lecture series a vote was taken to make it a permanent annual event.

INTEGRATED CORE PANELS

Los Angeles—The *Los Angeles* Section's February 19th meeting, held at the Rodger Young Auditorium, was one long to be remembered.

Approximately 65 members and guests enjoyed the presentation of a paper of exceptional quality and merit given by Alan Glasser, Airframe Research Defense Division, The Budd Co., Philadelphia. Mr. Glasser's subject was "Budd Integrated Core Panels, as Building Blocks of a Structural Concept." The paper, although rather long, was presented in a manner that held interest throughout its entirety. The paper covered a program of analytical development implemented by a broad test program which was carried on over a period of 3 years to determine the optimum geometry of the panels and to provide the basic structural concept for their most efficient use. The paper also discussed the considerations which led to the selection of a directional core panel and showed how certain unique advantages are obtained by the use of the panel, particularly in the field of "hot" structures.

The paper was well supported by technical data slides. Mr. Glasser also had a display of panels, so those present could observe the methods, techniques and configurations of the various panels produced to date.

Following Mr. Glasser's paper an interesting Pan-American Travel Film in color, titled "Fabulous Fishing in the South Seas," was shown.

WELDING STRUCTURAL METALS

San Jose—A very well-presented and well-attended series of six lectures was sponsored by the *Santa Clara Valley* Section. These lectures, presented from February 3rd through February 19th, were designed to inform engineers, shop supervisors, craftsmen and members of management of the metallurgy, processes and applications of welding structural metals.

The outstanding, able speakers and their subjects were as follows:

February 3rd—R. K. Sager, Aluminum Company of America, New Kensington, Pa., "Welding Aluminum and Aluminum Alloys."

February 5th—P. Klain, Dow Chemical Co., Midland, Mich., "Welding Magnesium and Magnesium Alloys."

February 10th—W. J. Baldwin, Allegheny Ludlum Steel Co., Los Angeles, Calif., "Welding Stainless Steels."

February 12th—R. Meredith, North American Aviation, Downey, Calif., "Welding Precipitation-Hardening Stainless Steels and High-Temperature Alloys."

February 17th—K. M. Spicer, International Nickel Co., New York, N. Y., "Welding Nickel Alloys."

February 19th—D. C. Martin, Battelle Memorial Institute, Columbus, Ohio, "Welding Reactive Metals: Titanium, Zirconium, Hafnium, Tantalum, Columbium, Beryllium and Molybdenum."

There were 146 participants who fully completed the series and each received a certificate of award.

BANQUET

San Jose—A banquet sponsored by the Santa Clara Valley Engineers Council was held in conjunction with the February meeting of the *Santa Clara Valley* Section, on Tuesday evening, February 26th, in the Hawaiian Gardens, San Jose. A very timely talk by General William W. Dick, Jr., Major General, G.S., on the performance of the Army and our responsibility to develop more efficient manpower, as well as tools, was heard by 310 members and guests.

The banquet was well supported by all societies of the Engineering Council, Industry and Educational Institutions in the Santa Clara Valley.

Colorado

ANNUAL DINNER DANCE

Denver—The annual dinner dance of the *Colorado* Section was held on December 12th at Cavaleri's Restaurant. A gay time was had by all.

WELDING POSITIONERS

Denver—The January meeting of the *Colorado* Section was held at Cavaleri's Restaurant on January 13th.

Speaker for the evening was Jack Jarms of the Harnischfeger Corp. Mr. Jarms spoke on the economy of welding positioners and their applications. He showed a number of slides illustrating his talk.

GRINDING

Denver—The *Colorado* Section held its February meeting at Cavaleri's Restaurant on February 10th. Speaker for the evening was Dick Horrocks of the Thor Tool Co. His talk on "Weld-Joint Preparation and Weld Finishing" covered several methods of grinding and also discussed the relative value of different kinds of grinding machines.

Connecticut

WHY WELDS FAIL

Bridgeport—Helmut Thielsch of the Grinnell Co., Providence, R. I., gave a very interesting talk on "Why Welds Fail" at the February 19th meeting of the *Bridgeport* Section held at the Robin Hood Restaurant.

TALKS ON WELDING OF STAINLESS STEEL

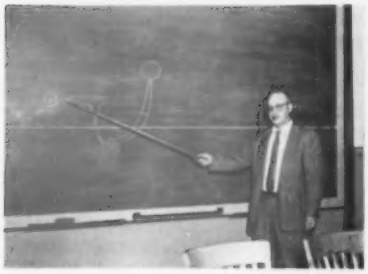
Russell Meredith was one of the technical speakers at the lecture course sponsored by Santa Clara Valley Section. His topic on February 12th was the welding of precipitation-hardening stainless steels

Pictured at the same meeting were (left to right) J. W. Weyers, Mr. Meredith, Section Chairman A. M. Hubbard, W. R. Smith and J. Turner

PARTICIPATE IN PEORIA EDUCATIONAL SERIES

Donald Harbers, Stan Nawrocki and Bob Kling (left to right) spoke on the application of T1 steel to off-highway hauling equipment

L. O'Day, Jim Howery, Al Dearing and G. E. Motzenbecker (left to right) discussed semiautomatic welding processes



Production use of inert-gas metal-arc welding equipment was explained by Hugh Reed

Mr. Thielsch used slides to illustrate his talk. He also injected some humor into his remarks to keep his audience in a more attentive mood.

Five points were covered in his remarks as follows: (1) Design specified on laboratory details is not sufficiently practical, i.e., there is a difference between laboratory specimens and actual conditions. (2) Inspection arrangements are not specified, i.e., choice of radiography process is left in the hands of the contractor. (3) Defects placed in material by manufacturer, i.e., laminations, roll overs, etc. (4) Lack of proper know-how in welding, i.e., improper joint design, electrode procedure, etc., (5) Adverse surface conditions.

POWER SOURCES

Glastonbury—On February 17th, the *Hartford* Section held its 5th regular meeting of the season at the Villa Maria Restaurant in Glastonbury.

After a cocktail hour and an excellent dinner, the members saw a movie on arc welding produced by Westinghouse Electric Corp. A short business meeting was called during which it was decided to contribute $50 a year for 3 years to the building fund of the new Engineering Center in New York.

The speaker for the evening was Emil F. Steinert, manager, Apparatus Engineering Section Welding Division, Westinghouse Electric Corp., where he is presently responsible for the design and development of all power-supply units related to electric-arc applications.

His subject was "Power Sources for Arc Welding." Mr. Steinert did an excellent job, starting with the history of arc-welding machines and bringing the audience straight through their development to the well designed units of today. The talk was illustrated by slides and was followed by a question-and-answer period.

Florida

NONDESTRUCTIVE TESTING

Miami—On February 18th, 81 members and guests of the *South Florida* Section and the *Florida* Section of the Society for Nondestructive Testing enjoyed a most interesting talk and demonstration on the "Future of Nondestructive Testing in Florida" given by Jesse Creech, technical director, Picker X-Ray Corp.

The meeting was held at the Jureit Associates Laboratory and was followed by a social get-together.

Illinois

EDUCATIONAL SERIES

Peoria—A very successful educational series, sponsored by the *Peoria* Section, came to a close on Tuesday, February 17th. The sessions were held in Jobst Hall at Bradley University. The subjects covered during this period were metals, electrodes and processes for steel fabrication.

The first session, held January 27th, covered "Application of T1 Steel to Off-Highway Hauling Equipment," with Donald Harbers, staff engineer, Caterpillar Tractor Co., Peoria Ill.; Stan Nawrocki, chief process engineer, Athey Products Corp.—"Welding and Forming of T1"; Bob Kling, vice president and chief engineer, Athey Products Corp.—"General Applications of T1."

The second session, dealing with "Classification and Use of Mild Steel Electrodes," was held on February 3rd. D. C. Helton, contact metallurgist, Harnischfeger Corp., was the principal speaker.

The third session, "Semiautomatic Welding Processes," was held on February 15th. The speakers and their subjects were as follows: L. O'Day, Peoria district sales manager, Lincoln Electric Co., "Submerged-Arc Welding," Jim Howery, technical service representative, National Cylinder Gas Co., "CO_2 - Shielded Flux-Covered Electrode Process," Al Dearing, welding engineer, A. O. Smith Corp., "CO_2 Welding"; G. E. Motzenbecker, Linde Co., "Gas-Shielded Magnetic-Flux Process."

The final session, covering "Production Use of Inert-Gas Metal-Arc Welding Equipment," was covered by Hugh Reed, welding engineer, International Harvester, Canton, Ill.

Indiana

WELDING MACHINERY

Fort Wayne—In conjunction with the membership drive of the *Anthony Wayne* Section, National Secretary Fred L. Plummer and Niels Miller, president of Miller Electric Co., were invited to speak at a dinner meeting held on January 27th for the top men in industry, in and around Fort Wayne, who are connected with the welding phase of the business.

Mr. Plummer spoke on SOCIETY membership, its purpose and advantages and the issuance of its publications.

Mr. Miller spoke on the manufacture of the a-c welding machine and his system of production. He also mentioned the use of the incentive plan for rate of pay and thus ended all discussion on welding as everyone was interested in learning more about this plan. His talk was quite interesting and humorous in the way the plan was started and the way it is operated.

LADIES' NIGHT

South Bend—Another very successful Ladies' Night meeting was held on February 19th by the *Michiana* Section. No doubt about it, the most important factor was the very interesting talk and demonstration given by Peter McKinney, public relations director of the Linde Co., Chicago, Ill. Mr. McKinney pointed out that many, many people—men in particular—have large investments in woodworking equipment for their hobby, but only a few do metal fabrication. This is probably due to the fact that most people believe the tools necessary are very expensive while, in fact, that is not so. For the price of a combination wood-working tool, one can purchase the torches, gases and auxiliary equipment for acetylene welding, brazing, soldering and copper enameling, and the possibilities for products are enormously larger.

By means of slides and samples, Mr. McKinney showed many of the types of things that can be made, but most interesting of all was the demonstration of copper enameling. Most books on this subject, the speaker said, do not mention the use of a torch for firing the enamel, but call for a kiln. This, of course, is much more expensive and not at all necessary for an amateur. Ash trays up to 6 in. in diam. can be successfully made using a torch with a No. 6 tip. As a crowning feature, Mr. McKinney presented each lady with a pair of hand-made earrings.

WELDED STEEL

Indianapolis—The February 27th meeting of the *Indiana* Section was held at Brodey's Village Inn, Indianapolis. A short business meeting followed the dinner.

Omer Blodgett, Lincoln Electric Co., gave an excellent talk on "The Efficient Use of Welded Steel." This talk was based on the paper that he had presented to the AMERICAN WELDING SOCIETY at St. Louis in 1958. The talk was accompanied by a number of slides.

This meeting was attended by 60 members and guests.

Maryland

ARC-WELDING FUNDAMENTALS

Baltimore—The *Maryland* Section met on February 20th at the Baltimore Engineers Club for dinner and meeting. Dinner speaker was Lieut. John Biemiller, an associate of the Baltimore City Police Department, and two K-9 police dogs.

Lieut. Biemiller gave a very interesting talk of the history and the work of the Corps and he was ably assisted by off-stage approval of Victor, a beautiful gray, tan and silver dog. The other and more friendly of the two dogs, Sergeant, was black and tan and not quite so large.

The dogs gave a demonstration on how they would detain an offender by working on a trainer who was in a very well-padded outfit.

Each team dog and officer are together on and off duty and the dogs, when off duty, are usually just a member of the family.

The feature of the evening was a talk given by Clarence E. Jackson, staff engineer, Linde Co., Newark, N. J., on the "Fundamentals of Arc Welding." Mr. Jackson covered the history of older tests which were used to determine quality of welds. He showed and described a number of slides illustrating electric circuits. He also showed charts of the actions of welds under the effect of current, voltage and time variations.

Massachusetts

HARD SURFACING

Springfield—The February 10th meeting of the *Western Massachusetts* Section was held as a joint meeting with the ASM Springfield Chapter at the Oaks Inn, Springfield, Mass. Despite inclement weather, there was an excellent turnout.

Following a fine dinner, a coffee film entitled "Deep Sea Fishing," featuring Ted Williams, was shown.

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ALUMINUM WELDING IS SUBJECT AT WORCESTER MEETING

Seated at the head table for dinner prior to the technical program on February 2nd are (left to right) Richard Childs, James Forand, Edward Hall, Ivan MacArthur, Chairman William Frye, William Ryngiewicz and Edwin Spellman

ager, Wall Colmonoy, Inc., presented an informative talk on "Hard Facing Materials and Techniques." His talk was accompanied by slides which showed various materials that are used in hard surfacing. The response given to his talk was indicative of the excellent presentation.

ALUMINUM WELDING

Worcester—Ivan A. MacArthur of Olin Mathieson Chemical Corp., New Haven, Conn., spoke at the February 2nd meeting of the *Worcester* Section held at the Tower House. Fifty-five members and guests turned out to hear Mr. MacArthur discuss "Aluminum Welding Past, Present and Future." There is a great future in the atomic industry for aluminum alloys especially the magnesium alloys of aluminum. Mr. MacArthur also covered in his talk many technical aspects of aluminum such as expansion, melting and the tough oxide.

Discussion finally had to be stopped at 11:00 P.M. in order to show a colored movie covering the building of a 50-ft yacht constructed entirely of aluminum.

The record turnout, coupled with the lengthy meeting, proved that Mr. MacArthur's talk was most informative.

Michigan

ARC-WELDING ELECTRODES

Grand Rapids—The February meeting of the *Western Michigan* Section was held on Monday evening, Feb. 23, 1959, at the Varsity Grille in Grand Rapids, Mich.

There were 35 present for the dinner and these were joined by four more for the coffee talk and Technical Session.

The coffee talk was given by Lieut. Robert Anderson of the Grand Rapids Police Department Vice Squad.

The Technical Session was conducted by Julian S. Kobler, supervisory welding engineer, at the U. S. Naval Gun Factory. Mr. Kobler's subject was "History and Development of Arc Welding Electrodes." He discussed a number of points in the development of these electrodes as well as the manufacture of electrodes and their coatings.

This was one of the Section's most interesting meetings and it was regretted that attendance was kept down due to very inclement weather.

TOPIC IS PRESSURE VESSELS FOR NUCLEAR SERVICE

At the February 12th meeting of the Kansas City Section, William R. Apblett spoke on pressure-vessel fabrication for nuclear service. Seated at the speaker's table are (left to right) C. J. Sise, Mr. Apblett, C. Meuche, J. R. Warn, Geo. L. Bond and L. L. Thompson

Missouri

PRESSURE-VESSEL FABRICATION

Kansas City—The *Kansas City* Section met for cocktail hour and dinner and meeting at the World War II Memorial Building on February 12th.

An excellent paper was presented by William R. Apblett, chief metallurgist of the Foster Wheeler Corp., New York. The title of his talk was "Pressure-Vessel Fabrication for Nuclear Service."

Mr. Apblett discussed tube welding as applied to steam-generator fabrication, austenitic weld cladding of carbon and alloy steels and notch ductility of base material and weld metal.

PROCESSES AND EQUIPMENT

Kansas City—The March meeting of the *Kansas City* Section was held at the World War II Memorial Building on March 12th.

Technical speaker was John Mikulak, assistant to vice president of manufacturing, Worthington Corp., Harrison, N. J. Mr. Mikulak described the processes and equipment necessary to produce heavy equipment and machinery. He also showed that design, manufacturing equipment and process application must be well coordinated if the goal of low-cost, quality products is to be achieved.

New Jersey

HIGH-STRENGTH STEELS

Newark—The *New Jersey* Section was honored at its February meeting by the presence of the second vice president of the SOCIETY R. David Thomas, Jr., as speaker. The dinner meeting was held at the Essex House on February 17th with

N. J. SECTION SPEAKER

The welding of high-strength steels was explained by 2nd Vice-president R. D. Thomas, Jr., at the February 17th meeting of New Jersey Section

an attendance of 60 members and guests at dinner and 94 at the meeting.

As president of Arcos Corp. and because of his prominent participation in development and research activities of the welding industry, he was able to bring before the audience much detailed information about his selected subject, "The Welding of High-Strength Steels."

Such steels known as HY 80, etc., must produce properties when weld assembled that surpass the requirements of many of the more ordinary types of welds. Explosive tests form one type of evaluation wherein the weld is expected to distend uniformly with the plate.

Mr. Thomas discussed the many factors of electrode composition with reference to attainment of weld properties, showing graphically that variations in ingredients brought about decisive variations in weld properties. He also discussed the effect of several operational factors such as electrode size, heat input and moisture. He particularly noted that the high, east coast summer humidity produced trouble in some types of welds due to moisture inclusion.

Following this presentation, the members gathered together for refreshments and renewal of acquaintanceship.

New York

BRAZING

New York—The second meeting of the year of the *New York* Section was held on February 10th.

SUSTAINING MEMBER

Moss Sheely, recently named Sustaining Member representative from Esso Standard Oil Development Co., dines with Andy Axtell (right) at a recent meeting of the New Jersey Section in Newark

The subject of the evening was "Brazing Challenges the Thermal Barrier," and the speaker was D. C. Herrschaft, assistant manager of Handy and Harman, New York.

The speaker gave a very interesting talk on present development in brazing of high-temperature alloys and brazing at temperatures in excess of 2000° F. Indeed, the title of the lecture certainly indicated a challenge of the "thermal barrier."

The products in which the processes are used primarily are components for jet planes as well as guided missiles.

Much has been, and will be, learned in the art of high-temperature brazing, and the importance of progress is necessary as the development of missiles and jets is progressing rapidly.

A good series of slides was shown which greatly simplified the understanding of the processes involved.

The meeting, as usual, was held at Victor's Restaurant, where an excellent dinner was served prior to the meeting. About sixty persons were present.

AUTOMATION IN WELDING

New York—On Tuesday, March 10th, the third regular monthly meeting of the *New York* Section was held at Victor's Restaurant, with an attendance of 60.

The speaker of the evening was J. H. Berryman, general sales manager of the Air Reduction Sales Co., who was assisted by his assistant, Robert Stone. The topic selected was "Automation in Welding," a subject that proved to be most interesting.

The speakers explained that great strides have been made in automation. Equipment has been constructed for full automatic operation, and manual equipment is also suc-

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cessfully revamped to fit automatic operation. Jigs and fixtures, although complicated, had to be developed to suit the new operations. Naturally, the more identical welds that are desired, the more complicated the setup becomes.

For example, the setup for the welding of launching equipment for guided missiles and satellites took considerable ingenuity on the part of the fabricators and welding experts.

The speakers explained the various controls used in automation; also, arrangement and selection of power supply.

A considerable number of slides was shown to illustrate the talk and an interesting question-and-answer period followed.

ARC WELDING

Albany—Nearly fifty members and guests were present for the Mar. 5, 1959 meeting of the *Northern New York* Section held at the Hot Shoppes Restaurant in Albany. Guest speaker for the evening was Carl E. Hartbower, chief of the Metals Joining Branch of the Watertown Arsenal, whose topic was "Arc Welding High-Strength Low-Alloy Steels."

Mr. Hartbower introduced his topic by relating a typical example of an Army ordnance application in which requirements were best met by using the proper low-alloy steels. As a result of proper selection of low-alloy steels, components that were both stronger and lighter in weight were able to be fabricated readily by welding. It is this latter aspect of the low-alloy steels that makes them such valuable materials. In the past it had been common practice to increase the strength of steel by increasing its carbon content; however, this was accompanied by a reduction in ductility and an increase in welding difficulties. Some years ago it was learned, though, that the properties of steel could be enhanced by the addition of minor amounts of alloying elements while carbon was maintained at a level of about 0.15%. These compositions led to steels having low-carbon martensitic structures. The resultant steels not only possessed higher tensile and yield strengths but also had excellent ductility and were able to be welded as readily as many of the common unalloyed, lower-strength carbon steels. Many of these high-strength steels can be satisfactorily welded without preheat and, for those in which it is required, it can be substantially lower than that

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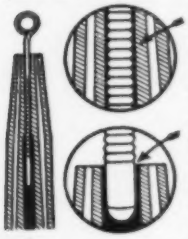

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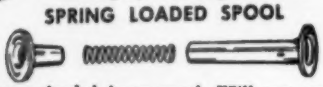

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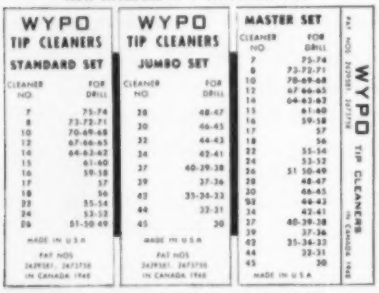

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which would have been required for a carbon steel of similar strength that was not of the low-carbon low-alloy type.

In addition to describing and illustrating the virtues of these steels, Mr. Hartbower also discussed several of the methods used for evaluating new materials, and also some fabricators use certain ones as a part of their acceptance testing of all incoming heats of steel. One notable example that was cited was that one large fabricator requires any steel that is to be welded extensively to pass a particular weldability test before it will be used. Those that fail are rejected. It is notable that welding difficulties in this fabricator's shop have been nearly nonexistent and are considerably less than that experienced by others making similar fabrications without first selecting materials on the basis of these weldability tests.

A lively discussion period followed Mr. Hartbower's formal presentation.

JOINT MEETING

Olean—Approximately 50 members and guests of the AWS and ASME sections in the Olean, Bradford and Wellsville area gathered on February 17th for dinner and a technical address by Emery Garriot, sales manager, Finished Products, Ampco Metals, Inc., Milwaukee, Wis.

Mr. Garriot spoke on "Jobs You Can Do with Bronze Electrodes and Filler Rods." He pointed out that composition of parent metal, service conditions, color matching and deposited metal physicals are all items to be considered before choosing the filler rod, electrode or even the welding process if a satisfactory job is to result. The speech was followed by a question-and-answer period. Mr. Garriot was presented a "Zippo" lighter by the Olean-Bradford Section Chairman—Jack Keyte.

CANCELLED MEETING

Olean—William H. Schuster, welding supervisor, American Car and Foundry Division, who was unable to reach Bradford, Pa., on January 20th due to the severe wintry weather, has agreed to give it another try on the 26th of May. The meeting will be held at The Castle, Olean, N. Y., with dinner at 6:30 P.M. and meeting at 8:00 P.M. Mr. Schuster will speak on "High-Speed Submerged-Arc Welding as Applied to Freight."

North Carolina

LIGHT-GAGE WELDING

Greensboro—The regular meeting of the *Carolina* Section was held on February 23rd at Stamey's Barbeque. There were 72 members and guests present.

Guest speaker was Don Helton of the Harnischfeger Corp. His subject was "Welding of Light-Gage Metal." He had a number of slides to illustrate the various points in his talk which were very interesting and informative.

Past-chairman Ralph Cope showed a film on "Applied Welding Engineering" and gave a brief talk on the activities and advantages of membership in the AMERICAN WELDING SOCIETY.

Ohio

FILLER METALS

Cleveland—Clayt Herrick, the technical chairman for the March 11th meeting, had a difficult time turning off the questions. The meeting would not break up in spite of a March blizzard blowing outside. The exceptionally interesting session was Harlan Meridith's discussion, titled, "Why Add Filler Metal?" Illustrated with slides and a movie, his talk described how his company, Airline Welding and Engineering, in Hawthorne, Calif., was developing equipment and methods for welding materials from 0.005 up to $^1/_2$ in. without adding filler metal. Most of the work is accomplished with automatic gas-shielded tungsten-arc welding although some of it is manual and some automatic submerged arc. The square butt joints in stainless steel, aluminum, magnesium, alloy steels and the exotic metals are welded for 100% penetration and then cold worked by roll planishing. The planishing redistributes the metal to give a nearly flat surface and perfect weld. Much of the work is done for the various California aircraft companies, although he showed an interesting application on hot water tanks.

At the meeting, Section Chairman Harry McBride presented to Wasil Romance the plaque awarded to the Cleveland Section's team of experts that won the annual "Stump the Experts" competition among the sections in Ohio. Besides Mr. Romance, the team consisted of Frank Kuntz, Loren Miller and John Diebold. The Cleveland Sec-

CLEVELAND SECTION HEARS TALK ON WELDING WITHOUT FILLER METAL

The welding of materials without addition of filler metal was discussed by Harlan Meredith at the March 11th meeting of the Cleveland Section. He is shown above (left) with Clayton Herrick, technical chairman of the Section

At this same meeting, a plaque was awarded to the Cleveland Section's team of experts that won the annual competition among the AWS Sections in Ohio. Left to right (above) are Section Chairman H. McBride, Wasil Romance, Loren Miller and Frank Kunz

tion's team has now won the plaque twice.

Bob Ellison, TV committee chairman, is working with one of the local TV stations on a quiz-type program for high-school students. The students, selected from local schools, will compete on the basis of a general knowledge of science. Mr. Ellison's committee is working on questions related to the sciences involved with welding for use on the program. The Cleveland Technical Societies Council is planning the program.

DISTORTION PROBLEMS

Columbus—On Friday, Mar. 13, 1959, the *Columbus* Section held its monthly Dinner Meeting and Technical Session. The subject for the evening was "Distortion Problems and How to Overcome Them." The speaker was J. R. Stitt, who holds the position of research and welding engineer with the R. C. Mahon Co., Detroit, Mich. Mr. Stitt gave a talk which was well illustrated by slides. He pointed out the importance of determining the proper welding sequence, and how this, combined with controlled predeflecting of the part, could prevent distortion. There was also a number of slides shown which illustrated how heat, if applied in the proper areas on a distorted part, could be used to straighten the part.

RESISTANCE WELDING

Toledo—The *Toledo* Section had an interesting program on" Resistance Welding" at its March 17th meeting. A. W. Schueler, of Precision Welder & Flexopress Corp. of Cincinnati, spoke on two subjects—"The Welding of Vinyl-Coated Steels" and "The Peco Foil Butt Seam Welding Process."

On the subject, "Welding of Vinyl Coated Steels," the speaker discussed the interesting problems of welding such a coated steel when the coating cannot become heated above 200° F. As an example, he showed a transistor radio case. The solution was reached by designing a resistance-welding machine to operate on weld time as fast as $^1/_3$ of a cycle. The machine was also designed to have a magnetically operated ram to furnish the "squeeze" at this short weld time.

"The Peco Foil Butt Seam Welding Process" is a process developed in Europe and relatively new to this country. Mr. Schueler discussed this process, pointing out the pros and cons, and compared the process to mash-seam welding and to flash-butt welding.

The process involves the introduction of a layer of foil above and below the butt joint. A typical example cited was 0.015 in. thick and 0.125 in. wide. The foil confines the current path, and compensates for minor unevenness of the joint. A conventional weld nugget is formed and the foil forms a solid-state bond with the base parts.

RESISTANCE-WELDING ELECTRODES

Warren—A highly informative talk on resistance-welding electrodes and materials was given before an enthusiastic audience of 43 members and guests at the February 19th meeting of the *Mahoning Valley* Section. Guest speaker was Edman F. Holt, metallurgist and welding engineer for P. R. Mallory Co., Indianapolis, Ind.

Prior to Mr. Holt's interesting program, an excellent color film complete with sound was shown during the after-dinner coffee hour at the El Rio Restaurant in Warren, Ohio. The film, "America's Favorite Boatride," covered a trip around New York City by one of the sightseeing boats found in the New York area. This film was also the first one to be shown on the new Bell and Howell movie projector recently purchased by this Section. They have also purchased a new slide projector, adaptable for all sizes of slides and a screen for their use.

This month's very educational dissertation by Mr. Holt covered the Resistance Welder Manufacturer's Assn. (RWMA) classes and groups of electrodes, including description of each type, manufacturing methods, physical and metallurgical properties, conductivity and various uses for each classification. He pointed out how these RWMA classifications were based upon alloying elements with copper as a

base. Heat treatment during manufacture was also discussed along with water-cooling requirements when welding.

With regard to electrode configuration, the various Morse tapers were mentioned and also slides were shown on shapes of tips and electrode faces and caps. Seam-welding wheel design and description were also covered along with threaded-type electrodes.

Slides on some unusual applications and materials such as Elkonite were also shown along with the latest type "Nu-Twist" holder design.

The Mahoning Valley Section recommends this excellent program.

Oklahoma

CORROSION TESTS

Tulsa—The March 4th dinner meeting of the *Tulsa* Section was held at the Alvin Plaza Hotel.

A semitechnical talk with slides showing how sample specimens are prepared for a corrosion test, which was all very interesting to the group, was given by J. F. Mason, Jr., of the International Nickel Co. Mr. Mason also told the group of the vast amount of information pertaining to corrosion and the welding of nickel products that they have available for their customers.

All indications were that this was a good meeting.

Pennsylvania

STRUCTURAL WELDING

Allentown—The March meeting of the *Lehigh Valley* Section held on March 2nd was a joint meeting with American Society of Civil Engineers and was held at Walps Restaurant, Allentown, Pa.

The ASCE, as host chapter, had as their speaker Carl L. Kreidler, chief structural engineer of the Lehigh Structural Steel Co., Allentown, Pa. Mr. Kreidler showed slides and spoke on the fabrication and erection of the structural steel for the Pan-American Passenger Terminal at the Idlewild Airport. Some of the architectural innovations of the terminal were a canopy over the plane loading area and ramps to permit direct access from the second floor into the plane by passengers. Some structural features were the elliptical shape of the building; welded tapered cantilever girders approximately 220 ft long and almost four acres of roof area.

The speaker told of the fabrication and erection problems that were encountered and how they were overcome.

SUBMERGED-ARC WELDING

Allen G. Hogaboom was the technical speaker at the February 2nd meeting of the Lehigh Valley Section. His topic was "Submerged-Arc Welding." Left to right are: L. R. Constantine, Mr. Hogaboom and Section Chairman C. D. Jensen

William B. Joachim, Jr., of the Lehigh Coal & Navigation Co., in his coffee talk, urged executives and engineers to participate actively in local politics.

J. M. Adams, ASCE chapter president, presided.

HEAVY WELDED STRUCTURES

Erie—James J. Dawson, quality control superintendent and chief metallurgist of the Ingalls Shipbuilding Corp., Pascagoula, Miss., was the guest speaker at the February 17th dinner meeting of the *Northwestern Pennsylvania* Section held at Nissen's Grill. Mr. Dawson's talk was on "Heavy Welded Structures" and covered techniques employed in the preparation of the material, its fitting, erection and welding.

FROM WELDING'S PAST

Philadelphia—The February 16th meeting of the *Philadelphia* Section started with a Section-sponsored cocktail hour, followed by dinner.

H. Schwartzbart, supervisor of Welding Research at Armour Research Foundation, was speaker for the evening. His subject was "Welding Glimpses into the Past and Future." Mr. Schwartzbart is a very capable speaker and gives the listener the impression that he enjoys his subject very much. His talk was full of reminiscence for the old timer and revelations for the newcomer.

Interesting were the old "Stove Pipe" and wooden helmets, wood preferred for safety. Interesting, too, were the many firsts such as the *Welding Engineer* magazine starting in 1916 as the first welding journal, the first AWS JOURNAL in 1922, the first welded vessel to fail and the first welded pipe line, the first book on theory, practice and testing of welding published in 1910 and the first welding shop, Baldwin Locomotive Works, 1910.

Mr. Schwartzbart briefly covered such new processes as ultrasonic, high-frequency resistance, vacuum, plasma-jet, friction and electro-slag welding.

PANEL MEETING

Philadelphia—The March 6th Panel Meeting of the *Philadelphia* Section created quite a discussion over the subject, "Inert-Arc Welding Copper Alloys."

The years of experience represented by the panel members and moderator no doubt accounted for much of the enthusiasm.

OUTLINES HISTORY OF WELDING

"Welding Glimpses into the Past and Future" was the subject of H. Schwartzbart's talk before the Philadelphia Section on February 16th. At pre-meeting dinner are (left to right) Past-chairman B. Gates; Mr. Schwartzbart; AWS 2nd Vice-president R. D. Thomas, Jr.; Section Secretary W. Wooding and Membership Chairman F. Hussey

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ANOTHER "IMPOSSIBLE" $5,000 SAVING WITH A "EUTECTIC" WELD

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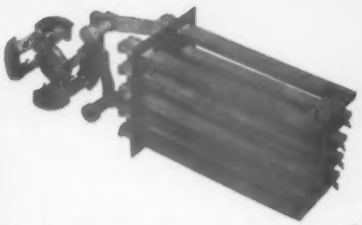
Welding had been considered and tests were made but conventional high heat welding materials produced cracks, "leakers" and stress formations.

The local "Eutectic" Technical Representative was called in, examined the block and recommended welding with Eutectic's Xyron 2-25. This is the newest and most advanced cast iron electrode for overlays and difficult repairs on heavy sections of gray and alloy cast iron. Non-cracking Xyron 2-25 produces dense, smooth, crack-free deposits without preheat. The deposit made is high nickel alloy specially balanced to prevent porosity and cracking. Ultimate tensile strength is 56,000 psi.

Xyron 2-25 has had widespread successful application in the repair of machine bases, cracked motor blocks, motor and gear housings, transmission cases, gears, cams and building-up of teeth in cast gears. It is extremely valuable in permitting welds without fusion or distortion of the base metal.

Weldors repaired this casting with Xyron 2-25 in 78 hours, including all machining and assembly.

Now, after more than six months of continual operation, no pressure leaks or defects of any kind can be found in the weld. The saving of $5000. and many weeks of non-operation, again points up the tremendous savings that are accomplished in over 100,000 plants by the utilization of Eutectic's "Low Temperature Welding Alloys."®



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In the manufacturer's own words, "...experience dictates use of EutecRod 1801...because its high joint conductivity permits low resistance connections, its strength assures good connections. Its low bonding temperature means simplicity, ease of application, and eliminates distortion, and its fast flow minimizes oxidation."

Xyron 2-25, available in 1/8", 5/32", 3/16" dia. Lt. Blue Tip, secondary — Silver. Standard weight shipments. • EutecRod 1801 in 1/64", 1/32", 3/64", 1/16", 3/32", 1/8", 3/16" dia. Strips of .020 x 3/32" — .025 x 1/8" — .010 x 1" — .005 x 1" — .005 x 1/2" — .003 x 1"

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WELDING OF COPPER ALLOYS COVERED BY PANEL

The March 6th panel meeting of the Philadelphia Section was devoted to inert-gas welding of copper alloys. Panel members are (left to right) J. Cunningham, S. D. Reynolds and P. L. Hemmes

Moderator for the evening was John Lang. He is shown (standing) in an informal conversation with Past-chairman R. D. Bradway and Section Chairman C. Schaub

J. A. Cunningham of Cunningham Equipment, Inc., showed and discussed a group of slides representing the aluminum-bronze hardsurfacing applications.

P. L. Hemmes, Research Dept., Revere Copper and Brass, Inc., spoke at length of the welding of copper-nickel alloys. Among other things, Mr. Hemmes pointed out the pros and cons of the globular and spray-type arc and the advantages of cold working for strength increase.

S. D. Reynolds covered the characteristics peculiar to the copper alloys, such as hot shortness, effect of heat input and corrections, proper heat treatment and techniques.

Moderator J. Lang, welding engineer, Lukenweld, Inc., gave his usual good performance.

STRUCTURAL STEEL

Philadelphia—One of the best presentations of the season was given at the *Philadelphia* Section meeting held on March 16th at the Engineers' Club. The address on "Everyday Welding Problems in the Fabrication of Structural Steel" was given by J. H. Hinkle of the Lincoln Electric Co.

Mr. Hinkle's theme concerned the proper selection of electrodes by type. He posed the question as to whether or not we in the welding industry were giving enough thought to the selection of the most economical type of electrode for the specific job or whether or not we were perhaps "sort of resting on our laurels" and using an old standby.

He explained what to look for or to consider when choosing the proper electrode and used as an illustration what he called the three "F's," namely, "fast fill," "fast follow" and "fast freeze." Quite an interest was shown in the question-and-answer period following the address.

Mr. Hinkle has been associated with the Engineering Department of the Lincoln Electric Co. for 13 years. His work has been in the fields of electrode and flux development and testing these developments for practical application. His current position is that of application engineer.

ANNUAL DINNER DANCE

Philadelphia—The *Philadelphia* Section of the AMERICAN WELDING SOCIETY calender for May will take on a slightly different atmosphere.

Following a very active and successful and, needless to say, serious program of technical meetings and panel discussions throughout the season, will come the Annual Dinner Dance to be held at the Germantown Cricket Club on May 23, 1959. Dom Mockus has assumed the responsibilities of Dinner Dance Committee Chairman.

This event presents a wonderful opportunity for the membership to enjoy an evening of fun and frolic with their wives and gals.

As this event heralds the close of the season's meetings, so, too, does it herald the end of a very well-selected calender of events for which the membership gives thanks to

SPEAKS ON WELDING OF STRUCTURAL STEELS

J. Hinkle described the everyday welding problems in the fabrication of structural steel at the March 16th meeting of Philadelphia Section. Front row (left to right) are Section Chairman C. Schaub, Mr. Hinkle, District Director E. E. Goehringer. Rear row, in same order, are W. Wooding, F, Iapalucci, B. Gates and D. Mockus

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PITTSBURGH SECTION PLAYS HOST TO NATIONAL OFFICERS

Director F. H. Stevenson, Director A. F. Chouinard and President G. O. Hoglund pose momentarily for the cameraman at the February 18th meeting of Pittsburgh Section

National Treasurer Harry C. Rockefeller appears to be enjoying the conversation. Immediately behind him are Ed Murphy and B. Motl

The spirit of joviality seems to be contagious. Left to right are National Secretary F. L. Plummer, Director H. E. Miller and 2nd Vice-president R. David Thomas, Jr.

Director J. N. Alcock (left) shown in conversation with C. P. Weber

Guest speaker C. W. Lytton (extreme left) converses with President Hoglund. In background, between them are H. R. Cameron and K. Thornberry

Caught in pleasant conversation are (left to right) Directors Chouinard, J. H. Blankenbuehler and H. E. Schultz

Section Chairman Carl Schaub, Vice-chairman Frank Iapalucci and Panel Chairman Al Young who did a marvelous job of producing the panel discussions.

SUBMERGED-ARC WELDING

Pittsburgh—The *Pittsburgh* Section was host to 17 members of the National Board of Directors at their dinner in Webster Hall Hotel on Wednesday evening, February 18th, and at the regular monthy meeting in the Mellon Institute Auditorium.

The officers present were G. O. Hoglund, C. I. MacGuffie, R. D. Thomas, H. E. Rockefeller, F. L. Plummer, J. J. Chyle, F. J. Mooney, T. C. Dempsey, C. E. Jackson, J. H. Blankenbuehler, R. M. Wilson, Jr., H. E. Miller, J. N. Alcock, E. C. Miller, A. F. Chouinard, F. H. Stevenson and H. E. Schultz.

A basic presentation on a process comparison level on the subject of "Submerged-Arc Welding" was very ably given by C. W. Lytton, district manager for the Lincoln Electric Co., and L. A. Colarossi, welding engineer for Pittsburgh-Des Moines Steel Co. Mr. Lytton stressed the fundamentals and Mr. Colarossi the primary procedures and costs.

Following the regular meeting, a coffee hour was enjoyed by the members and guests in one of the lounges of the Mellon Institute.

Rhode Island

REGIONAL WELDING CONFERENCE

Providence—The Third New England Regional Welding Conference, "Better Quality and Greater Profits Through Welding in New England," was sponsored by the Providence Section on Oct. 23, 1958, at the Plantations Club in Providence, R. I.

The all-day conference consisted of Educational Sessions in the morning and Technical Sessions held in the afternoon with the following speakers:

9:45 A.M.—"Structural Welding," Thomas Kavanagh, consulting engineer, Praeger-Kavanagh Co., New York City.

10:45 A.M.—"Welding of Tanks, Pressure Vessels and Piping," Fred Plummer, Secretary, AMERICAN WELDING SOCIETY, New York City.

11:45 A.M.—"Cost Cutting Through Welding," E. L. Smith, New England district manager, Lincoln Electric Co., Boston.

2:00 P.M.—"Inspection of Weldments in ASME Code Pressure Vessels and Piping by Authorized Inspectors," T. R. Hardin, Hartford Steam Boiler Inspection and Insurance Co., Hartford.

3:00 P.M.—"Welding for Nuclear Service," William Bunn, Com-

NEW ENGLAND REGIONAL CONFERENCE ADDRESSED BY PLUMMER

National Secretary Fred L. Plummer spoke on the welding of tanks, pressure vessels and piping at the Third Annual New England Regional Conference

Helmut Thielsch, Chairman of Providence Section, introducing speakers at head table after evening banquet. Conference was held on Oct. 23, 1958

bustion Engineering Co., Chattanooga.

4:00 P.M.—"Brazing for High-Temperature Service," George S. Hoppin III, General Electric Co., Cincinnati.

George W. Kirkley, Chairman of the Hartford AWS Section, was chairman of the morning sessions. Sidney Low, Director of District No. 1, AMERICAN WELDING SOCIETY, was chairman of the afternoon sessions.

Simultaneous with the Technical Sessions in the afternoon, welding demonstrations were held on present-day welding techniques with explanations on welding of stainless steel by Crucible Steel Co., aluminum by Aluminum Company of America, cast iron by Chapman Valve Co. and piping by Grinnell Co., Inc.

These were very successful and attracted a large number of welders and other shop personnel.

In the evening a banquet was held, which was followed by a brief review by the National Secretary, Fred Plummer, of the services offered by the AMERICAN WELDING SOCIETY. Subsequently, G. O. Hoglund, National President of the AMERICAN WELDING SOCIETY, addressed the audience on the "Growth and Increasing Importance of Welding to Industrial Progress." A final talk on "Qualification and Training of Welders" was given by Roger Clark of the General Electric Co. The introductions were made by Helmut Thielsch, chairman of the host Providence Section.

Arrangements for the whole program were under the chairmanship of Avery Seaman, vice chairman of the Providence Section.

In spite of a severe rainstorm, 251 individuals registered for the Conference. The Technical Sessions were attended by 233 persons. Moreover, 143 persons were present at the banquet.

The Providence area has become active in the AMERICAN WELDING SOCIETY for only a little more than a year. A charter was granted to the newly formed Providence Section in June 1957. Members of the Providence Section and visitors alike agreed that this New England Conference was an outstanding success and has contributed materially to the recognition of welding in this area.

WELDING CODES

Providence—On Dec. 10, 1958, the *Providence* Section held its monthly meeting at Johnson's Hummocks. The dinner meeting was attended by 58 members and guests. Featured speaker was National Secretary Fred L. Plummer who reported on the affairs of the SOCIETY. He stressed the workings of the SOCIETY's technical committees and how the best engineers in the country are working under its auspices, preparing manuals and rewriting the specifications to keep pace with the modern trends. There are 92 technical committees now responsible for the SOCIETY's technical papers, codes, etc. Mr. Plummer expressed a very bright future for all of welding with the AWS having a large part in its future.

The technical speaker was James F. Lincoln, chairman of the board of the Lincoln Electric Co. Mr. Lincoln spoke on today's welding codes and how they restricted the use of welding in many instances. Mr. Lincoln speaks with the knowledge of 52 active years in welding to draw on. Our present-day codes have produced a "get tough" attitude with welding, and ask for almost impossible conditions to be attained by welds. He believed that the way to accomplish a better understanding was to educate the public. The restrictions that are placed on welding are unfair to the companies that depend on welding today, due to the added expense of a number of tests that could be eliminated. He pointed out the many restrictions in the standards set up for welding, and emphasized that until the changes are made in the present codes, progress in the industry will be slowed down. Mr. Lincoln's talk was followed by a very active discussion period.

BRAZING AND BRAZE WELDING

Providence—On January 21st, the *Providence* Section met at Johnson's Hummocks for their monthly dinner meeting and technical lecture. The dinner meeting was attended by 39 members and guests. Among the guests attending the meeting was the chairman of the Boston Section, Walt Ovaska, who was thanked for his help and assistance during the recent Regional Conference.

The guest speaker of the evening was Arthur N. Kugler, chief welding engineer of the Air Reduction Sales Co.

Mr. Kugler spoke on the basic difference between brazing and braze welding in terms of the standard AWS definitions. He went on to stress the importance of the precleaning and postcleaning opera-

HUNTING IN ALASKA

David Uihlein (left) points out a significant area during his talk on an "Alaskan Hunting Trip" as Nashville Section's Program Chairman, Russell Staub, lends a hand

tions, as well as the fluxes and filler metals used in the two processes.

Although brazing is one of the oldest processes used for joining metals by heat, it is being used today quite frequently by the aircraft industry in the development of our supersonic aircraft sections. Mr. Kugler's very informative talk was supplemented by a very interesting selection of slides.

BRAZING

Providence—On Wednesday evening, February 18th, the *Providence* Section met for dinner and meeting at Johnson's Hummocks.

The technical speaker was D. C. Herrschaft, assistant manager, Brazing Products Division, Handy & Harman, New York City. Mr. Herrschaft gave an informative talk on the brazing procedures and techniques applicable to mass and small scale production brazing involving furnace brazing, induction brazing and flame-brazing methods. By means of various slides, he illustrated proper joint-preparation methods, including the use of shims and inserts. Mr. Herrschaft also discussed in detail the various brazing alloys now being used and several new developments applicable to the brazing of carbides.

Tennessee

AUTOMATION

Nashville—The February meeting of the *Nashville* Section was held on February 12th at Cross Keys Restaurant with 47 members and guests present. Two door prizes, a portable outdoor barbecue grill and an imported bar set, were presented to George Merrick of Temco and L. L. Barlow of Nashville Bridge, respectively.

David Uihlein, president of Banner Welder, Inc., Milwaukee, Wis., was the guest speaker. His subject, "Automation in Spot Welding," was illustrated with moving pictures and covered the various automatic welding machines that his company manufactures.

After his technical talk, Mr. Uihlein presented a very interesting 35-minute film on an Alaskan hunting trip.

Texas

ELECTRODES

Houston—Eighty-four members and guests of the *Houston* Section were present at the February 25th meeting held at the Houston Engineering-Scientific Society Building.

Wilbur H. McGrew, Air Reduction Sales Co., spoke on the topic "Mild-Steel and Low-Alloy Electrodes."

ALUMINUM ALLOYS

Dallas—On Friday, March 13th, the *North Texas* Section was privileged to have as guest speakers President G. O. Hoglund and National Secretary Fred L. Plummer.

Mr. Plummer briefly discussed the activities of the SOCIETY in publishing the WELDING HANDBOOK and the various standards.

Mr. Hoglund discussed the properties of the aluminum alloys. Illustrating his talk with a group of interesting slides, Mr. Hoglund pointed out a number of areas in which welded aluminum is being used in unfired pressure vessels and in structural applications.

Eighty-six members and guests attended the dinner meeting at Amon Carter Field.

Utah

WELDED WHEELS

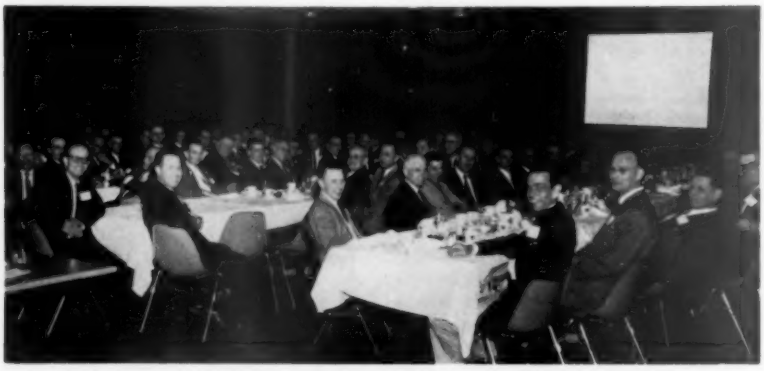
Salt Lake City—The February 19th meeting of the *Salt Lake City* Section was held at the Tower House with 30 members present.

Guest speaker was Paul E. Tade, sales and service engineer for Sciaky Brothers, Inc., of Los Angeles. Mr. Tade gave a very informative talk on "The Manufacture of Spot-Welded Automobile Wheels," after which he presented a 16-mm color film on the same subject.

This was a very interesting and educational meeting.

MILD-STEEL AND LOW-ALLOY ELECTRODES DISCUSSED

Wilbur H. McGrew discusses "Mild-Steel and Low-Alloy Electrodes" before Houston Section



Partial view of the dinner gathering prior to the technical talk by Mr. McGrew which followed. Close to 100 members and guests attended

Wisconsin

OXYGEN CUTTING

Madison—The *Madison* Section met on March 12th at the Eagle's Club.

Dinner was served at 6:30 and was followed by a slide presentation, entitled "Around the World in 86 Days." Making the presentation was coffee speaker Maurice White, associate professor of Agricultural Journalism at the University of Wisconsin. Professor White recently traveled around the world and recorded his travels on slides.

Technical speaker for the evening was Raymond Fish, welding superintendent of the Harnischfeger Corp., Milwaukee, Wis. Mr. Fish presented the findings and experiences of his company in the use of liquefied petroleum and natural gas for preheat flames in oxygen cutting. A film was shown depicting cutting with natural gas preheats. Robert Meyer, also of the Harnischfeger Corp., assisted Mr. Fish in answering questions of the 50 members in attendance.

An enjoyable and educational evening was had by all.

HOGLUND AND PLUMMER ADDRESS NORTH TEXAS SECTION

Left to right are Al Bernson, Secretary F. L. Plummer, Jim Bland, Cliff Moss, President G. O. Hoglund, Al Kennedy, George Werner, P. V. Pennybacker, Bill Irwin, Jay Collins and Ed Mai at the March 13th meeting of North Texas Section

Eighty-six members and guests attended the meeting to hear talks by Secretary Plummer on Society activities and by President Hoglund on the welding of aluminum

EMPLOYMENT OPPORTUNITY FOR ENGINEER

AWS is seeking an engineer to join Headquarters' Technical Staff as Assistant to the Technical Secretary.

Here is an opportunity—

The man we are seeking has initiative and imagination and is interested in becoming familiar with welding in all its aspects and for every type of application. Salary will be commensurate with qualifications and experience.

If interested in being interviewed for this position, send a resume* of your education, experience and personal background to

Technical Secretary
American Welding Society
33 West 39th Street
New York 18, N. Y.

* Will be held confidential.

For details, circle No. 18 on Reader Information Card

New Members

EFFECTIVE MARCH 1, 1959

MEMBERSHIP CLASSIFICATION

A—Sustaining Member
B—Member
C—Associate Member
D—Student Member
E—Honorary Member
F—Life Member

TOTAL NATIONAL MEMBERSHIP

Sustaining Members	198
Members	6,034
Associate Members	5,666
Students	211
Honorary Members	9
Life Members	15
Total	12,133

ANTHONY WAYNE

Scheele, Albert H. (B)

ARIZONA

Reilly, William P., Jr. (C)

BOSTON

Hammond, Walter C. (B)
Turner, John L. (C)
Wharen, Harry S. (B)

BRIDGEPORT

Csaky, Bert (B)

CANADA

Norton, A. D. (B)

CAROLINA

McGee, Thomas G. (C)

CHICAGO

Hanson, Donald C. (B)
Thompson, George Wm. (C)

CLEVELAND

Beach, O. Marvin (B)
Carver, Gerford (B)
Crouse, Robert J. (B)
Diener, James S. (C)
Kapel, Tony (B)
Wischhusen, John (C)
Wright, Patrick (C)

DAYTON

Long, Harold (B)
Peterson, Leonard C. (B)

DETROIT

Appleby, Gordon (C)
Baer, Simon S. (B)
Johnson, Robert H. (B)
Lynch, William (B)
Rado, Julius (B)
Timms, Thomas A. (C)

EASTERN ILLINOIS

Veach, Rex H. (C)

HARTFORD

Robinson, George C., Jr. (C)

HOUSTON

Beard, James B. (C)
Stevens, Lee M. (C)
Wiseman, W. L. (C)

INDIANA

Blanck, Kenneth F. (C)
Reed, Thomas B. (C)

IOWA

Gathercole, Edward F. (B)

IOWA-ILLINOIS

Boyer, Kenneth H. (B)

J. A. K.

Eckert, Robert C. (C)
Flynn, Jerry (C)

LEHIGH VALLEY

Gibson, J. R., Jr. (B)
Lutz, Ira T. (C)
Saunders, Carl G. (C)

LONG BEACH

Davis, Allan (C)
Burnette, L. E. (B)
Hawkins, Robert L. (C)

LOS ANGELES

Cortilyou, Bob (D)
Glidden, Bruce (B)
Kent, Anthony R. (D)
Lohara, C. S. (D)

MAHONING VALLEY

Hammar, Donald K. (B)
McCann, John E. (B)
Pavlich, Steven E. (B)

MARYLAND

Mosner, Oliver L. (C)
Tibbels, Charles Morris (C)

MILWAUKEE

Patrick, Donald E. (C)
Verhein, Donald (B)

NASHVILLE

Busby, John T. (C)

NEW JERSEY

Cagnoni, G. James (B)
Fleury, Alfred F. (B)
Fodor, James (B)
Oldershaw, William Davis (B)
Vanaman, Adrian O. (B)

NEW YORK

Garvey, Charles Milton (C)
Graffam, Marcellus W. (B)
Mussman, Nathan (B)
Olshever, Robert (D)
Rogers, R. L. (B)
Rudd, Wallace C. (B)

AWS Builds Men of Welding

Vogel, Harry L. (B)

NORTH TEXAS

Fenton, John D. (B)
Harrison, T. G. (C)

NORTHWEST

Hexum, Curtis A. (B)
Mikkola, Clifford J. (B)

PASCAGOULA

Brouillette, Herbert J. (B)
Murray, Herman A. (C)
Parham, Earl W. (B)

PEORIA

Robinson, Raymond M. (C)

PHILADELPHIA

Archer, George Richard (B)
Burnett, Guy M. (B)
Enzman, August J. (B)
Galletly, George W., Jr. (B)
Hillman, Donald B. (C)
Kudelko, Arthur G. (B)
Vishio, John Joseph (B)

PITTSBURGH

Bonassi, John J. (B)
Ghrist, E. J. (B)
King, William D. (C)
Layman, Fred W. (C)
Lessmann, Gerald G. (C)
Mumper, James H. (B)
Reinfeld, Kurt (B)
Rodich, Milo E. (C)
Zevada, Michael J. (C)

PORTLAND

Goff, Vyril D. (B)
Phetteplace, Dennis R. (D)
Ward, Millard O. (D)

PROVIDENCE

Morin, Joseph A. (C)

PUGET SOUND

Tompkins, Sam (B)

RICHMOND

Lucy, John C., Jr. (C)
Robbins, William Bruce (C)

SAGINAW VALLEY

Anderson, David G. (D)
Colliton, James L. (B)
Shoskey, Gerald J. (B)

ST. LOUIS

Schmidt, Harold H. (C)

SALT LAKE CITY

Hansen, Douglas D. (D)
McCann, Oscar M. (D)
Leatham, George S. (C)
Winward, Reed A. (D)

SAN ANTONIO

Donatto, Ation (B)

SAN FRANCISCO

Beck, Clifford A. (D)
Henderson, Lee A. (C)
King, Robert Loren (B)
Leader, Clifford F. (B)
Newburn, Ruie E. (B)
Newman, Luther E. (B)

SANGAMON VALLEY

De Fevers, Bryce D. (C)
Garmers, George (C)
Goin, Robson M. (C)

SANTA CLARA VALLEY

Brocker, Ray L. (C)
Hawkinson, Leroy T. (B)
Hiatt, Robert F. (B)
Kawaguchi, Makoto (C)
Kirk, John W. (C)
Mejia, Mario J. (B)
Neal, Joseph S. (B)
Pappani, Arnold E. (C)
Pierce, Fred M. (B)
Pledger, Paul (C)
Roberge, Ted (C)

SHREVEPORT

Prince, Alton R. (B)
Schmidt, R. V. (B)

SOUTH FLORIDA

Sharlow, E. K., Jr. (C)

STARK CENTRAL

Dean, Darwin E. (A)

Hargrove, Robert M., Jr. (B)
Stanley, James D. (B)

SYRACUSE

Evans, Richard L. (C)
Farden, Donald J. (C)

TOLEDO

Belair, Howard James (B)

WESTERN MICHIGAN

Stinson, Walter L. (C)

YORK-CENTRAL PA.

Slaney, Joseph T. (C)

MEMBERS NOT IN SECTIONS

Crossman, A. W. C. (B)
Neale, John Sidney (B)
Trujillo, Carlos (B)
Vloeberghs, Paul (B)
Waters, John David (B)

Members Reclassified During March

BIRMINGHAM

Durstine, John E. (C to B)

DETROIT

Payne, William B. (C to B)

LEHIGH VALLEY

Martin, Allen (C to B)

NORTHERN NEW YORK

Wu, Keh Chang (D to C)

NORTHWESTERN PA.

Mioduszewski, Chester (C to B)

PITTSBURGH

Misko, Michael (C to B)

ROCHESTER

Hawxhurst, M. W. (C to B)

TULSA

Clay, George R. (C to B)

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PAGE 545

FOR ANY STAINLESS WELDING JOB

Drawalloy
CORPORATION

Stainless Steel Welding Wire

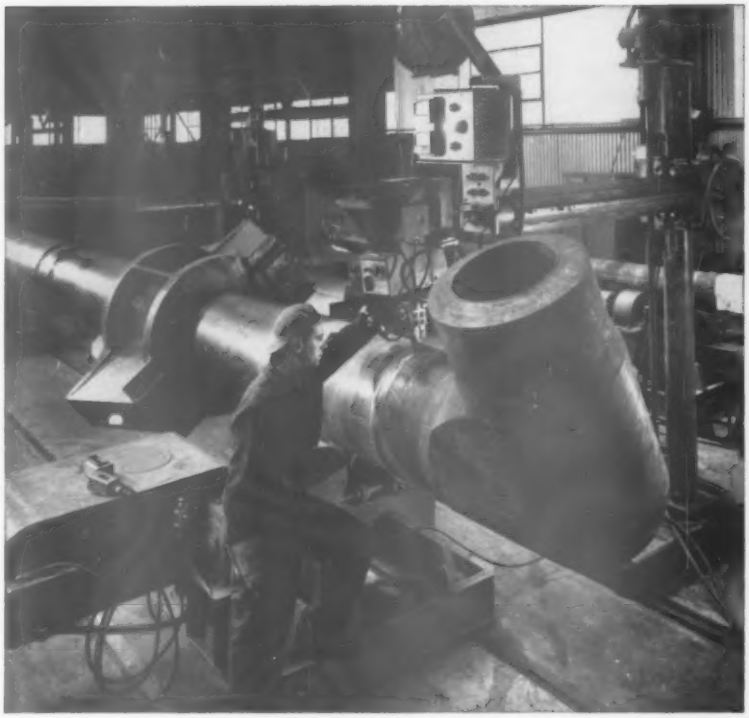

Photo courtesy of National Valve and Manufacturing Company, Pittsburgh, Pa.

Specify Drawalloy "quality controlled" stainless steel welding wire for *your* next "quality weldments." Your greatest advantage is experience . . . our experience in producing wires for welding exclusively. Because we are specialists, Drawalloy stainless steel welding wire is produced to strictly controlled specifications to provide the right chemistry, finish and temper for the finest quality weld metal and smoother operation in your automatic or semi-automatic equipment. Drawalloy stainless wires are available in all popular grades as well as 2¼ Cr, 1 Mo; 1¼ Cr, ½ Mo.

Why not discuss your stainless welding wire needs with your Drawalloy Distributor or Representative . . . a man with the products and knowledge to help you. Bulletin 355 DC provides complete information on every grade of Drawalloy wire. Write to: Drawalloy Corporation, Lincoln Highway West at Alloy Street, York 13, Penna.

DRAWALLOY
CORPORATION
STAINLESS STEEL & TOOL STEEL WELDING WIRE

THE WIRE MILL FOR THE WELDING INDUSTRY
For details, circle No. 19 on Reader Information Card

NEWS of the industry

Summer Conference in Welding Engineering Planned at Ohio State University

A conference course in the "Fundamentals of Welding Engineering" will be given by Ohio State University during June 15–26, 1959, in Columbus, Ohio. The 10-day course will be conducted in the university's Department of Welding Engineering and will make use of the department's laboratory equipment and Davis Welding Library. All instruction will be given by the faculty of the Columbus school. Professor Roy B. McCauley, chairman of the department, will be largely responsible for the subject of materials; Dr. Robert C. McMaster will provide coverage of equipment, processes and nondestructive testing; and William L. Green will deal primarily with the design phase of welding.

Tentatively scheduled lecture topics during the first week will include an introduction, welding machine and characteristics, properties and atomic structures of materials, gas and flux-shielded arc welding, filler materials, gas welding and cutting, metallurgy of plain-carbon steels, weld discontinuities, heat treating plain-carbon steels and flow-bond welding. The second week will consider such subjects as residual stresses and distortion, welding of plain-carbon steels, resistance welding, welding of alloy steels, welding of nonferrous materials, welding symbols, testing of welds, procedure and performance qualifications and welding design.

Punctuated with short quizzes, the welding conference will be terminated with a final examination on June 26th. Successful completion of the course by the registrant will result in the issuance of a certificate from the College of Engineering.

No specific prerequisite training or experience is required in order to enroll for the courses. Registration must necessarily be limited to a maximum of forty. Registrants will be accepted in the order in which their registration requests are received. A fee of $150 will cover the tuition for the conference course. Registration request forms may be obtained from W. L. Green, Department of Welding Engineering, The Ohio State University, 190 W. 19th Ave., Columbus 10, Ohio.

ASM Introduces Course in Arc Welding

Designed for both welding technicians and production, sales and managerial personnel within the industry is "Arc Welding," latest addition to the home study curriculum of the Metals Engineering Institute, a division of American Society for Metals.

Editor and coordinator of the subject matter is Clarence E. Jackson, staff engineer of the Newark laboratory of Linde Co.

"Arc Welding" covers all forms of the process. Subjects in the home-study and in-plant training course include fundamentals such as weldability, power supply and equipment, consumable and nonconsumable electrodes, mechanical properties, design, quality control and other topics.

Taught also are techniques themselves and applications in high-alloy steels, copper and its alloys, aluminum, magnesium, titanium and nickel alloys.

Detailed course information on "Arc Welding" may be secured from the Metals Engineering Institute, American Society for Metals, 7301 Euclid Ave., Dept. NR-3, Cleveland 3, Ohio.

Kaiser Plans Move to California

Kaiser Aluminum & Chemical Corp. has announced that it plans to move its general sales offices from Chicago to Oakland, Calif.

According to John Menz, vice-president for marketing, bringing together of all of Kaiser Aluminum's

COMING EVENTS

A Calendar of Welding Activity

AWS National Meetings

1959 National Fall Meeting: September 28–October 1. Sheraton Cadillac Hotel, Detroit, Mich.

41st Annual Meeting and Eighth Welding Show: April 25–29, 1960. Biltmore Hotel, Los Angeles, Calif.

SESA

May 20, 21, 22. 1959 Spring Meeting and Exhibition. Sheraton Park Hotel, Washington, D. C.

NEMA

June 4–5, 1959. Arc Welding Section Quarterly Meeting, Hot Springs, Va.

ASM

Nov. 2–6, 1959. 41st National Metal Exposition and Congress. International Amphitheatre, Chicago.

Lincoln

WELDYNAMICS

NEWS ABOUT ARC WELDING AT WORK CUTTING COSTS

Better quality, lower cost when Lincoln mild steel wire and alloy fluxes are used on high pressure pipe.

HOW FLORI PIPE CONTROLS QUALITY AND COSTS . . . MEETS DELIVERY DEADLINES

Keeping quality up, costs down and still maintaining delivery of prefabricated pipe sections is a tough job for anyone. But even on such vast piping jobs as Tidewater Oil Company's Delaware refinery it is all in a day's work to the Flori Pipe Company of St. Louis, Missouri. Flori is one of the nation's leading fabricators of high pressure pipe for the petroleum and petro-chemical industry.

Flori's Welding Engineer is Ken Notvest. He is responsible not only for welding methods and procedures; but also for maintaining the high degree of welding quality required on the special alloy pipe work in which Flori specializes.

Jetweld LH-70 gives 99% X-ray acceptance.

Mr. Notvest has developed some excellent procedures for manual welds. He uses Fleetweld 5-P, a Lincoln E-6010 electrode, for root beads in carbon steel pipe and follows with Jetweld LH-70, a low hydrogen E-7018, for cover passes. This gives them 99% X-ray acceptance on open gap welds without backing rings.

After testing many different electrodes for this application Mr. Notvest believes Jetweld LH-70 to be superior for deposition rate, appearance, out-of-position welding, and as-welded low temperature impact strength.

Flori also has many automatic submerged arc welding applications in their pipe fabricating plant. They once welded alloy pipe with alloy wire and neutral flux. However, as a result of a survey conducted in the plant by John Lucas, a Lincoln welding engineer, they have found that Lincoln alloy fluxes (mixed especially for them), and mild steel wire cut material costs by two-thirds—cut welding time in half and make better welds.

Mr. Notvest claimed, "When we invited the Lincoln man to survey our operations we had no idea that the result would make such substantial savings."

For cost reduction ideas and help with procedures, call your Lincoln welding engineer today.

Ken Notvest, Flori's Welding Engineer, examines a weld from the inside with the "Bore Scope" he designed and built.

The LINCOLN ELECTRIC CO.

Dept. 1955 • Cleveland 17, Ohio

The World's Largest Manufacturer of Arc Welding Equipment

For details, circle No. 20 on Reader Information Card

Job report courtesy of
Superior Welding Company, Decatur, Ill.

When requirements demand *more than* the "*ordinary*" in Stainless Welds

WELD WITH ARCOS

STAINLESS ELECTRODES

This vessel shell will become part of a high vacuum melting furnace. It is constructed of 304 ELC stainless steel except for supporting lugs and minor fittings of carbon steel. The stainless section was welded with Arcos CHROMEND K-LC Electrodes to assure sound, leak-free welds under high vacuum operating conditions. The chemical analysis of Arcos CHROMEND HCN proved highly successful for joining the dissimilar base metals—carbon and stainless steels. On *any* job, Arcos quality will pay you the dividends that come from a job well and reliably done. ARCOS CORPORATION, 1500 South 50th Street, Philadelphia 43, Pa.

For details, circle No. 21 on Reader Information Card

policy-making groups in management, production, sales and market development in one headquarters will make possible more coordinated and effective action in the selling era that lies ahead in the aluminum industry.

"It will enable the corporation," Mr. Menz said, "to further increase its marketing effectiveness, and to speed up decisions on situations involving more than one department of the corporation's management. Not only will it strengthen the corporation's ability to participate in the development of more new applications of aluminum, but it will also enable us to provide better service to aluminum users."

The move to Kaiser Center in Oakland will be accomplished in planned stages, with completion scheduled for about September 1st.

Alloy Rods Expands Field Force

According to E. R. Walsh III AWS, vice-president in charge of sales for Alloy Rods Co., five additional field representatives have been assigned to new territories. Each of the men has completed the company's six-month training program at the main plant in York, Pa. In the East, Eugene F. Weisser, a Villanova graduate, has been assigned to Philadelphia and Fred J. Rex, Jr. AWS, a Vermont alumnus, will cover the Pittsburgh area. Two of the men have been sent to Chicago—they are Robert M. Alexander and Robert F. Mann, respective graduates of Gettysburg and Rider. The fifth new assignment sends Weldon E. Spangler, a graduate of Penn State, to Houston.

Sperry Conducts Special School

Representatives of many of the nation's largest corporations recently attended a special ultrasonic inspection school at Sperry Products, Inc., Danbury, Conn.

The school was organized to meet the need for a better understanding of ultrasonics and its many inspection possibilities. The basic theory of ultrasonics and principles of its inspection application were presented in classroom lectures supplemented by discussion periods. Actual practice in the operation of equipment was supplied in several laboratory sessions.

In addition to the Danbury school, Sperry conducts other ultrasonic inspection schools at its regional branch laboratories in Pittsburgh, Chicago and Los Angeles.

Liquid Carbonic Holds Welding School

The Liquid Carbonic Division of General Dynamics Corp. recently called in half of its field engineers and salesmen for a 2-week educational course. Under the direction of Edward J. Vogel AWS, technical sales director, the students were given a comprehensive engineering seminar on compressed gases at the company's Chicago plant. Subjects covered included study of new applications of liquefied gases, physical properties of gases, technical servicing of welding equipment, functions and design of oxyacetylene regulators, industrial piping and compressed-gas economics.

A. O. Smith Opens Southern Branch

The A. O. Smith Corp., Milwaukee, Wis., opened a new Southeast branch Product Service building, 754 Miami Circle NE, Atlanta, Ga., on March 1st.

Located in the Piedmont-Southern Industrial Center, the A. O. Smith building has 12,000 sq ft of floor space, including 2400 sq ft of air-conditioned space for offices and product training facilities. The building will handle product service for Georgia, Mississippi, Tennessee, North and South Carolina, Alabama and Florida.

J. P. Thomas AWS, the company's welding products sales representative, also will move into the building.

In addition to parts and repair service for the company products, the building will house training facilities.

Fibre-Metal Forms West Coast Subsidiary

Fibre - Metal Products Co., Chester, Pa., has announced the formation of a new subsidiary, Fibre-Metal Pacific, Inc., to warehouse and wholesale welding acessories and safety equipment in the seven western states of Washington, Oregon, Idaho, California, Nevada, Utah and Arizona.

Effective May, 1, 1959, Fibre-Metal Pacific will commence its operations at 7332 S. Garfield Ave., Bell Gardens, Calif., selling exclusively to distributors of welding and safety supplies and equipment. Included in the company's inventory will be products manufactured by Fibre-Metal, Glendale Optical and J. N. Ragle.

H. V. (Vern) Gates AWS, formerly with Jackson Products, has been appointed general manager of the new firm, and will be an officer of the company.

Job Report Courtesy of Electric Boat Division, General Dynamics Corp., Groton, Conn.

For maximum weld strength at sub-zero temperatures

WELD WITH ARCOS

LOW ALLOY ELECTRODES

The Skate (above), as well as the Nautilus, Seawolf, Swordfish, Skipjack and Triton are among the "greats" in America's atomic powered sub force carrying welds produced by ARCOS low alloy electrodes. ARCOS Tensilend 80, 100, 120 and Ductilend were used to assure welds of highest possible impact strength whether on missions in the tropics or the sub-zero arctic. When you need weld metals with similar qualities, ARCOS is well worth remembering. ARCOS CORPORATION, 1500 South 50th Street, Philadelphia 43, Pa.

For details, circle No. 22 on Reader Information Card

PERSONNEL

Long Named President of Taylor-Winfield

At the recent annual meeting of the Board of Directors of the Taylor-Winfield Corp. in Warren, Ohio, Theodore S. Long AWS was elected president and general manager of the resistance-welding manufacturer, succeeding J. Denton Anderson who became chairman of the Board and chief executive officer.

A 1930 graduate from the University of Michigan, Mr. Long has been a director of Taylor-Winfield since 1939. Since 1944 he had been vice president and general manager of the Warren firm.

President of the Resistance Welder Manufacturers Assn. in 1948, Mr. Long is currently chairman of the AWS Exposition Committee and is also a member of the SOCIETY's Manufacturers and Reserve Funds Committees. In addition, he is Taylor-Winfield's AWS Sustaining Member representative.

McBurney Elected IAA President

L. L. McBurney, president of Smith Welding Equipment Corp., Minneapolis, was elected president of the International Acetylene Assn. at the 61st annual convention in New Orleans on Tuesday, March 10th.

One of the oldest technical associations in the country, the IAA was organized to develop broader and more useful applications for calcium carbide, acetylene gas and applied products, and to disseminate information on such developments.

Elmer H. Smith, chairman of the board of Smith, served as president of the association from 1937 to 1939.

Mr. McBurney, who was vice-president of the IAA, is regional vice-president of the National Association of Manufacturers, and is active in other professional and civic organizations. He joined Smith in 1925 and served as general manager and sales manager before becoming president in 1949.

Franks Named by Electric Boat

Ernest H. Franks AWS has been named operations department welding engineer at General Dynamics Corp.'s Electric Boat Division.

Mr. Franks will be responsible for providing technical guidance, direction and assistance to all departments and personnel concerned with production welding in the operations department.

A native of Philadelphia, Mr. Franks was graduated from Drexel Institute of Technology with a degree in mechanical engineering in 1941. The same year he joined the industrial test laboratory at the Philadelphia Naval Shipyard.

He remained at Philadelphia until he joined General Dynamics. During this time he served as a mechanical engineer, a welding engineer and a physical metallurgist.

A registered professional engineer in Pennsylvania, Mr. Franks has authored two technical papers on welding.

Fred G. Outcalt

Outcalt Promoted to International Post

Fred G. Outcalt AWS has been appointed sales manager, Linde Department, Union Carbide International Co., Division of Union Carbide Corp.

Mr. Outcalt has been with Linde since 1928. He was active in the development and introduction of steel "deseaming" or "scarfing"; and various oxyacetylene welding, cutting and stress-relieving applications. He became most widely known in the welding industry through his activities with "Unionmelt" electric welding and was issued several patents on equipment and methods relating to this process. He was manager of Linde's Unionmelt Department until a few years ago when he became assistant manager of the Electric Welding Department which was formed to consolidate all of Linde's electric-welding activities including Heliarc, Sigma and Unionmelt welding. More recently Mr. Outcalt has been working with Unionarc welding, Heliarc cutting and other new Linde processes and products.

Mr. Outcalt was graduated from the University of Pennsylvania in

S.T. Long

L. L. McBurney

E. H. Franks

1923 with a Bachelor of Science degree in Civil Engineering. He spent some time as an officer of the United States Coast and Geodetic Survey and as a construction engineer with the U. S. Pipe and Foundry Co. before joining Linde.

Meredith Joins Weldfab

Russell Meredith AWS has joined the staff of Weldfab, Inc., Gardena, Calif., as vice president in charge of Engineering, Research and Development.

Long associated with welding in the aircraft industry, Mr. Meredith began his career with Lockheed in 1933. He moved on to Douglas in 1936 and then to Northrup in 1939, where he remained until 1951, the year he was named a process engineer at North American Aviation. Mr. Meredith became a senior-research engineer with the company's Missile Division in 1952. From 1953 to 1954 he was a lead engineer. Between 1954 and 1956, he was supervisor of the Materials Research Welding Group, having been elevated to group leader late in 1956.

Mr. Meredith was largely responsible for the welding of turbine rotor assemblies, heat-resisting alloys for gas turbines and hollow sheet-metal compressor blades. In 1944 he was issued a patent on the welding of magnesium and magnesium alloys by an electric arc in helium- and argon-shielded atmospheres, using a tungsten electrode.

Also in 1944, Mr. Meredith received the James F. Lincoln Arc Welding Award.

Cross and Fenske Promoted

At their recent board of directors meeting in Chicago, William W. Jetter AWS, president of Mid-States Welder Mfg. Co., announced the elections of George W. Cross and Otto E. Fenske, Jr., to the respective positions of vice president of operations and vice president of sales.

Lehmkuhl, Boyer and Vaught Promoted at Arcair

The following promotions have been made by the Arcair Co., with headquarters in Lancaster, Ohio.

Elmer Lehmkuhl AWS has been appointed sales manager. He will be responsible for marketing and sales of all Arcair products in the company's Eastern Division.

Martin Boyer is the new sales promotion and advertising manager for Arcair.

Elmer Lehmkuhl

Durward B. Vaught has been assigned as the Arcair Co. field representive in Virginia, Kentucky and Southern West Virginia in addition to other Southern states which comprise his sales district.

Jeffers Named by Liquid Carbonic

William R. Jeffers AWS has been appointed District Sales Manager, Cincinnati District, for the Liquid Carbonic Division of General Dynamics Corp. Mr. Jeffers has been associated with the welding industry for many years.

Hastings and Wright Transferred by Lincoln

Donald F. Hastings has been named district manager in Moline, Ill., for the Lincoln Electric Co. Mr. Hastings moved to Moline from San Francisco where he was a welding engineer with Lincoln for nearly five years. He is a graduate of Pamona College and Harvard Business School and completed a one-year training program at the company's Cleveland plant before going to California.

Donald G. Wright AWS has moved from Chicago to replace Mr. Hastings in California. A graduate of Mount Union College, Mr. Wright has been with Lincoln since 1955.

Kissler Named by Linde

Laurence Harvey Kissler AWS has been appointed supervisor of distributor sales in the Salt Lake City District by Linde Co., Division of Union Carbide Corp.

He had been a sales representative

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in the same office since 1956.

Mr. Kissler joined Linde as a sales representative at Seattle in 1951, and later held similar positions in the Eugene and Portland, Ore. offices.

Mr. Kissler earned a B.A. degree in business administration and Master's degree in Economics from Washington State.

Neiley Appointed by Sperry Products

Sperry Products, Inc., Danbury, Conn., has announced the appointment of Richard Y. Neiley as assistant industrial sales manager for the company.

Mr. Neiley joined Sperry Products in 1953 as a commercial engineer. He became sales office supervisor in 1955, coordinator of sales in 1956 and Chicago district sales supervisor in 1957.

Mr. Neiley attended Colgate and was graduated from Holy Cross. He later attended graduate school at the University of Geneva in Switzerland.

Ludwig Joins International Nickel

John N. Ludwig, Jr. has been appointed supervisor of Metallurgical Services of the International Nickel Co., Inc. Mr. Ludwig's headquarters are at Inco's Pittsburgh, Pa. office.

Formerly associated with the Electro Metallurgical Co., a division of Union Carbide Corp., for 21 years, Mr. Ludwig has had many years of service with the steel industry. In his new capacity with International Nickel, he is available to give technical assistance to the users of primary Inco nickel in the production of nickel-containing materials.

Linde Assigns Four Men

Linde Co., Division of Union Carbide Corp., has announced four new appointments in its Pacific Coast Region.

Edward P. Miller was named manager of distributor sales in the Los Angeles District; Donald H. Thorpe, manager of distributor sales in the San Francisco District; Edward William Scott, manager of distributor sales in the Pacific Northwest District with headquarters in Portland, Ore.; and John William Dickinson, manager of electric welding engineering in the Pacific Northwest District at Seattle, Wash.

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OBITUARY

Merrill Good

Merrill "Ken" Good died suddenly on January 25th after a heart attack suffered at his desk. He was 47 years old.

Born on Dec. 29, 1911, in Toledo, Ohio, Mr. Good joined Hobart Brothers in 1944 in the electrode sales department and was subsequently appointed sales manager.

Mr. Good was a member of the Dayton Section of the AMERICAN WELDING SOCIETY and had been a very active member of the Section's membership committee.

John Hila

John Hila passed away at Elizabeth General Hospital, Elizabeth, N. J., on Jan. 26, 1959. He was 48 years of age.

Mr. Hila joined the Foster Whee-

John Hila

ler Corp. in Carteret, N. J., in June 1928 as a layout and setup man and continued to serve the company until his recent death. He became a supervisor in 1942 and was a department superintendent for over seven years. His final position was that of welding supervisor.

A past chairman of the New Jersey Section of the AMERICAN WELDING SOCIETY, he was also a member of ASM and ASME. Within the company, Mr. Hila was a member of the Foster Wheeler Supervisor's Club and the Twenty-Five Year Club.

He is survived by his wife, two daughters and a son.

Paul Klain

Paul Klain died March 3rd in Los Angeles' Cedars of Lebanon Hospital. He was 49.

Mr. Klain joined the Dow Metallurgical Laboratory as a metallurgist in 1940 and rose to become leader of the Fabrication Development and Joining Group of its Metallurgical Development Section. He was the author of numerous papers and holder of three patents in the field of magnesium welding.

Paul Klain

He was a member of several of the AMERICAN WELDING SOCIETY'S national committees and was the current chairman of the Saginaw Valley Section, which he helped organize in 1947–48. He was also a member of the American Society for Metals.

Mr. Klain was born in Sonta, Austria, on Aug. 6, 1909, and came to the United States in 1921. He was graduated from Wayne University in 1935 with the degree of bachelor of science in chemical engineering. He received a master of science degree in metallurgical engineering from the University of Michigan in 1936.

Prior to becoming associated with Dow, he was, successively, a metallurgist with Packard Motor Car Co., Detroit, and a research metallurgist with Battelle Memorial Institute, Columbus, Ohio.

He is survived by his widow and three sons.

Raymond F. Sherwin

Raymond F. Sherwin died in Victory Memorial Hospital, Waukegan, Ill., on March 9th. He was 60.

Born in Chicago, Feb. 28. 1899, Mr. Sherwin joined the Chicago Hardware Foundry Co. North Chicago, Ill., shortly after World War I. He became manager of the Welding Rod Division just before World War II and was named assistant secretary in 1952. His elevation to the board of directors followed a year later.

Mr. Sherwin contributed to the growth of the "CHF" Welding Rod Division and was responsible for the development of a new type cast-iron copper-nickel rod. A member of the AMERICAN WELDING SOCIETY, he was also an active member of the AWS-AFS committee on welding iron castings and on the subcommittee "X" for AWS-ASTM on filler metal.

He is survived by a son and a brother, Frank J. Sherwin, president of the Chicago Hardware Foundry.

W. Sigmund

W. Sigmund, executive vice president of Eutectic Welding Alloys Corp., Flushing, L. I., N. Y., passed away on Feb. 28, 1959.

W. Sigmund

Mr. Sigmund had been with Eutectic for the past seventeen years and contributed much to the steady growth of the company. He had extensive knowledge of international banking and finance and took an active part in the world-wide operations of the company.

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adjacent the gap edges and at positions shortly in advance of the welding point at which pressure is applied to close the gap in the metal tubing. A radio frequency current is supplied to the contacts so that current flows from the contacts along the gap edges and to and from the welding point. A conductor extends from one of the contacts circumferentially of the tubing to the other of the contacts so that a portion of the radio frequency current will flow through the conductor and induce a voltage circumferentially in the tubing opposing the voltage that causes current to be conducted from one contact circumferentially of the tubing around to the other contact.

2,827,546—Method and Device for Cooling Electric Resistance Welding Machines—Frank Fruengel, Hamburg-Rissen, Germany.

This new patent is on the method of electric resistance welding wherein a pair of welding electrodes are pressed towards opposite outer surfaces of workpieces with a force great enough to provide desired pressure between the inner contacting surface of the workpieces. A current impulse is sent through the electrodes to melt portions of the workpieces between the electrodes, which current impulse is great enough to create an electro magnetic force to cause ejection of a portion of the molten material from the welding zone so as to cool the welding zone so that the total thickness of the workpieces located between the electrode is reduced by ejection of a portion of the molten material therefrom.

2,827,547—Apparatus for Welding Vehicle Frames—Julius B. Tiedemann, Milwaukee, Wis., assignor to A. O. Smith Corp., Milwaukee, Wis., a corporation of New York.

This patent covers an apparatus for welding the longitudinal seam of an elongated article. It includes a welding fixture for receiving a frame for welding action, a flexible track having a curvature in general conforming with the longitudinal contour of the rail on the frame to be welded, and weld head means provided to ride along the track for weld action.

2,827,548—Apparatus for Welding—Walter R. Griswold, Chicago, Ill., assignor to A. O. Smith Corp., Milwaukee, Wis., a corporation of New York.

This patent relates to the positioning of a welding electrode in welding alignment with a seam to be welded. The apparatus includes a welding head positioning an electrode, and a finger member adapted to engage the seam to be welded and position the electrode a given distance therefrom. Hydraulic means are provided to bring the finger member into engagement with the seam or to retract it from engagement therewith.

2,827,549—Adapter for Making Arc Welds with Inert Gas Atmosphere—George L. Carlson, North Bergen, N. J., assignor to Coast Metals, Inc., Little Ferry, N. J., a corporation of Delaware.

Carlson's adapter and new equipment is of the class where a welding head is supported above a workpiece and is moved parallel to the workpiece along a path corresponding to an edge to be welded. The welding head includes special means therein as well as a cooling water jacket enclosing an electrode guide sleeve.

2,827,550—Gas Shielded Nozzle for Arc Welding Head—Ralph R. Unrath, Milwaukee, Wis., assignor to A. O. Smith Corp., Milwaukee, Wis., a corporation of Wisconsin.

This novel welding head nozzle is adapted to be positioned immediately adjacent an arc in the arc spatter zone. The welding head nozzle is made from a heat-resistant thermosetting resin selected from certain specified materials. This nozzle is adapted to prevent the build up of arc spatter thereon.

2,827,551—Method of Fabricating Tubes for Heat Exchangers—Malcolm W. Orr, Jr., Signal Mountain, and Thomas L. Mabery, Chattanooga, Tenn., assignors to Combustion Engineering, Inc., New York, N. Y., a corporation of Delaware.

In this patent, a method for making tubular elements having laterally extending tab-like fin means thereon is disclosed. These fin means are bonded to the tube by moving an electric arc along the juncture of the fin means and tube with the arc and heat zone produced being of sufficient intensity to fuse the fin means and tube together. The arc is discontinued at frequent locations along the fin and thereafter lateral slots are provided in the fin means at these locations.

2,827,552 — Platen Construction Method—Viggo Berthelsen, Copenhagen, Denmark, assignor to V. Berthelsen Engineering Works, Inc., Joliet, Ill., a corporation of Illinois.

Berthelsen's patent is on a method of constructing a labyrinthed platen and it includes positioning a pair of arcuate plates with the convex faces thereof opposed and successively inserting partition strips between the faces of the arcuate plates with the alternate strips staggered. Each partition strip is welded to the plates along the lateral edges of the strip and proper pressures are successively applied to the concave faces of the plates between the partition stripe to reform the intermediate portions of the plates into substantially parallel relationship.

2,828,120—Apparatus for Reconditioning Welded Pipe Flanges, Preparing the Ends of Pipe for Welding to Pipe Flanges or Other Lengths of Pipe—Raymond C. Porter, Cincinnati, Ohio.

The present patent comprises a machine for rotatably supporting a tubular workpiece and wherein the machine is adapted to take tubular members therein of appreciably varying diameters. The apparatus is adapted to cut the workpiece with a cutting torch and prepare pipe ends for welding flanges thereto.

2,828,406—Apparatus for Fusing Surface of Slab—Robert E. Kinkead, Youngstown, Ohio, the Cleveland Trust Co., executor of said Robert E. Kinkead, deceased, assignor to the Cleveland Trust Co., Cleveland, Ohio, a corporation of Ohio, as trustee.

In this patent, the inventor disclosed a process for making clad metal articles wherein a layer of coating metal is welded over a side surface of a slab of a base metal and any defects resulting from microshrinkage in the layer of coating metal that might cause surface defects after subsequent rolling of the coated slab, are thereafter eliminated. Such elimination is secured by bringing an inductive heating means into inductive relation with the surface of the layer of coating metal and supplying current to the heating means after which the slab and heating means are moved relatively for progressively melting a thin portion of the surface of the entire layer of the coating metal. The current supply is regulated and the rate of relative movement of the slab and heating means are so controlled as to confine the melting within the thickness of the layer of coating metal without melting the junction between the coating metal and the base metal.

2,828,472 — Magnetic Welding Ground Clamp—George J. Wondriska, Chicago, Ill., assignor to Magne-Cast Tool Co., Inc., Chicago, Ill., a corporation of Illinois.

The patented ground clamp includes a magnetized block for removable attachment to a ground piece. The block has an arm extending therefrom and a ground connector member is carried by the arm so that a ground conductor can be rotatably engaged with means on the arm to provide a ground connection for said block.

2,829,078 — Flux Composition — Henry B. Aull, Livingston, and Albert Stanley Cross, Berkeley Heights, N. J.

The present novel flux composition is of the alkali metal fluoride-borate type. It includes about 0.3 to about 10% by weight of a member from the group consisting of a water insoluble boron compound, finely divided boron, titanium, aluminum, magnesium, manganese and zirconium metals.

2,829,233—Automatic Gap Control Device for Hydraulically Actuated Flash Welders—Kingsley A. Doutt, Alpena, Mich.

The present patent related to a device for controlling the flashing current supply circuit of a flash welder so that a preselected gap is present between the workpieces. Special members are provided movable with the workpieces and motion limiting means are provided in association with such members. Special switches are provided in the apparatus and are actuated by the movable means associated with at least one of the workpieces to control the welding current supply dependent upon the relative positions of the workpieces.

2,829,234—Slagforming Body for Use in Butt Welding—Willem Pieter van den Blink, Utrecht, Netherlands, assignor, by mesne assignments, to North American Philips Co., Inc., New York, N. Y., a corporation of Delaware.

This patent relates to a provision of a ferrule for use in butt welding a metallic pin to a metallic surface and wherein the ferrule is positioned on the end of the pin and has a strengthening strip secured to the outer surface of the ferrule. The ferrule protrudes axially beyond the pin and is adapted to adhere to the pin during the initial burning of the arc flame.

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New Literature

Welding Catalog

A new catalog of welding products has been combined with an informative guide to welding practice in a 32-page brochure just issued by the Arcos Corp., 1500 S. 50th St., Philadelphia, Pa. It describes the firm's full line of stainless-steel, low-alloy, nonferrous rods and electrodes for manual, automatic and semiautomatic welding.

Known as the "Welding Guide and Catalog," the publication has been designed to aid the welder in the selection and use of welding electrodes and rods. All products are given in chart form, together with specific information on each brand name listed. Pertinent information includes such facts as forms available, description, usual welding applications, AWS-ASTM designations, popular name type, heat-treatment data for maximum properties, preheating data and tensile properties.

Technical guidance on successful welding performance is given in a section entitled "How to Get Better Stainless Steel Welds" and by a chart on "Effect of Alloying Elements on Weld Metal Properties."

For your free copy, circle No. 40 on Reader Information Card.

Plasma-arc Torch

An 8-page booklet, Linde "Plasmarc" Plating, describing the new plasma-arc service for metals in the high-temperature range, has just been issued by the New Products Department, Linde Co., Division of Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.

The Linde Co., developers of the plasma-arc torch which operates at temperatures up to 30,000° K. engages in both the coating and fabrication of shapes for industries using ultra-hard materials such as pure tungsten, molybdenum, zirconium and tantalum, as well as stainless steel and other metals. The new torch service has already been extensively used in connection with the manufacture of parts for missiles, rockets, electronic and nuclear components, and other parts used in civilian as well as military fields.

For your free copy, circle No. 41 on Reader Information Card.

Resistance-welding Electrodes

The Resistance Welding Alloy Assn., 1900 Arch St., Philadelphia 3, Pa., has released "Production Progress Through Resistance Welding," a six-page leaflet on the importance of resistance welding to profit-minded, progress-minded metal fabricators.

The brochure presents to the metal-working industries the time and money-saving advantages of production by resistance welding and the role of quality electrodes and specialized alloys to production progress.

For your free copy, circle No. 42 on Reader Information Card.

Electronic Line Tracer

New bulletin N142-R-3 describing the NCG "Electronic Line Tracer" attachment for oxygen-cutting machines has been published by the National Cylinder Gas Division of Chemetron Corp., 840 N. Michigan Ave., Chicago 11, Ill.

The bulletin lists advantages of the new control system for the firm's Type R cutting machines in which optical sensing techniques are used to guide metal-cutting torches by scanning or reading pen or pencil line drawings.

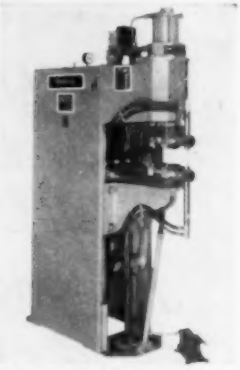
According to the manufacturer, the tracer unit—developed by Canadian Westinghouse Co.—features high accuracy, easy operation and greater safety because it can be used in well-lighted areas. Because the scanning "eye" will cross lines, it also reportedly makes possible new drafting techniques in which the torches move from one shape-cutting operation to the next without interruption.

Construction details, principles of operation and typical applications are also included.

For your free copy, circle No. 43 on Reader Information Card.

Resistance-welding Machines

A new line of press-type spot and projection welding machines is covered in Brochure P59, offered by the Federal Machine and Welder



Co., Warren, Ohio. In color, this illustrated booklet gives complete description and includes specifications covering the four available sizes, ranging in capacity from 30 to 500 kva.

For your free copy, circle No. 44 on Reader Information Card.

75th Anniversary Issue

To commemorate their 75 years in business, Harnischfeger Corp., 4400 W. National Ave., Milwaukee 46, Wis., has issued a 20-page booklet entitled "Harnischfeger Today."

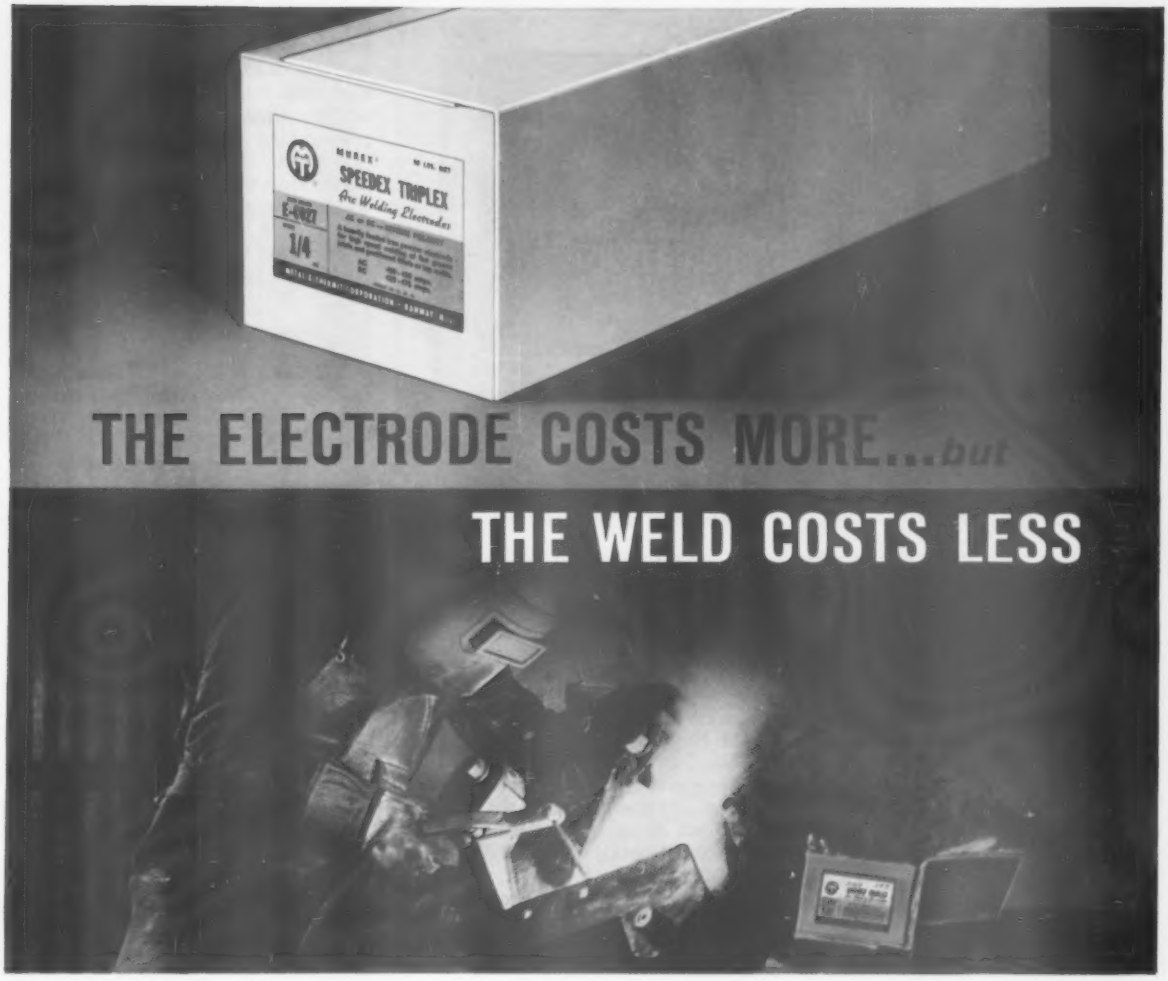
Included in the attractive publication are many photographs in color illustrating the company's products. The 9- x 12-in. booklet describes the operations of many of the firm's divisions, including welding, industrial, diesel engine, and construction and mining.

For your free copy, circle No. 45 on Reader Information Card.

Silver Market

Handy & Harman, 82 Fulton St., New York 38, N. Y., have published their 43rd annual review entitled "The Silver Market in 1958." Included in the 24-page, 5-x 7-in. booklet are statistics from the New York Market, U. S. imports and exports, lend-lease silver, treasury free stocks, the London Market, the Bombay Market, a summary world demand and supplies, and a general outlook for 1959.

For your free copy, circle No. 46 on Reader Information Card.



See how downhand welding costs go down with Speedex Triplex iron powder electrodes

Comparable electrodes:	Conventional 5/16" E-6020	1/4" Triplex
Electrode cost per lb.*	$0.160	$0.220
Melt rate, lb. per hr.	16.60	22.40
Cost of metal melted per hr.	$2.656	$4.928
Deposit rate, lb. per hr.	11.75	17.31
Metal cost per lb. of deposit	$0.226	$0.285
Average hourly labor cost	$2.51	$2.51
Labor cost per lb. deposit	$0.213	$0.145
Cost of labor and electrodes per lb. deposit.	$0.439	$0.430

Now add your overhead and the faster production makes the saving all the more substantial

*1,000-20,000 lb. price

WITH heavy weldments that can be fabricated in the downhand position, a cheaper electrode proves no real economy. Not when you can deposit better than 17 pounds of metal per hour for a lower *end cost* with Speedex Triplex electrodes.

Compare the representative figures on comparable electrodes. No question but that you save money.

Fastest of the MUREX® line, Speedex Triplex modified E-6027 electrodes have an extra heavy iron powder coating. They produce X-ray quality welds with either drag or open arc technique. Ask the MUREX Man about them. Or send for bulletin. METAL & THERMIT CORPORATION, Rahway, New Jersey.

MUREX
PRODUCTS FOR BETTER WELDING

For details, circle No. 27 on Reader Information Card

For details, circle No. 28 on Reader Information Card

Index of British Welding

The Institute of Welding, 54 Princes Gate, Exhibition Rd., London, S. W. 7, England, has recently published an *Index to Transactions of the Institute of Welding and Welding Research*.

It is a comprehensive subject and author index to the 16 volumes of the *Transactions* issued between 1938 and 1953 and to the seven volumes of *Welding Research* published for the British Welding Research Assn. between 1947 and 1953.

Most of the results of the researches undertaken by the Welding Research Council of the Institute and by the British Welding Research Assn. before 1953 were published in the *Transactions* (until 1946) and *Welding Research*. This combined Index affords ready reference to all this material, much of which is of lasting technical importance.

Copies may be obtained from the Institute for 25*s*. plus 1*s*. postage.

Metal-working Products from Holland

The Association of Metalworking Industries, 13, Nassaulaan, The Hague, Holland, has published its Product-book 1958 in French, English, Spanish and Dutch. According to the association, the publication gives a survey of the products manufactured in the Dutch metalworking industry. Included are a list of products, a register of manufacturers and an index of trade names. The information has been combined from more than 70% of the organized Dutch metal-working companies.

For your free copy, circle No. 47 on Reader Information Card.

Nickel-base Brazing Alloy

A new single-page $8^1/_2$ x 11-in., two-color engineering data sheet (No. 5) discussing W. G. Nicrobraz, a nickel-base brazing alloy for joining stainless-steel surfaces with large clearances, is now available from Stainless Processing Division, Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich.

Nominal composition, metallurgical properties and engineering properties of the powder are listed. Methods of applying W. G. Nicrobraz and limitations to be observed are included.

For your free copy, circle No. 48 on Reader Information Card.

Welding for Aluminum Tank Trailers

Based on current production trends, one of every two tank vehicles in the nation soon may be aluminum, according to a prediction by Aluminum Company of America.

The forecast, based on current purchasing trends in the tank trailer field, is contained in the forward of a new booklet designed to aid the welding shop which must maintain and repair light metal transport rigs.

"A Manual for Maintenance and Damage Repair of Aluminum Tank Trailers" was prepared by Alcoa in cooperation with several aluminum tank manufacturers. It discusses repair needs ranging from rebuilding major accident damage, to closing seeper leaks. . . from altering brackets, to making extensive modifications.

The profusely illustrated booklet basically is a specialized welding manual. Such subjects as joint preparation, shielding gases, aluminum alloys, welding techniques and choice of welding electrodes are discussed. Eight tables, many of which present diagrams of edge preparation and dimensions, are presented. There are more than 30 black and white pictures of actual welding sequences and preparatory steps.

For your free copy, circle No. 49 on Reader Information Card.

Nondestructive Testing

Volume 7, No. 1, of "Magnafacts" is now available from Magnaflux Corp., 7300 W. Lawrence Ave., Chicago 31, Ill. Included in this Winter 1959 issue is a 2-page illustrated article on the use of nondestructive testing in tank welding at B-I-F Industries at Providence, R. I.

For your free copy, circle No. 50 on Reader Information Card.

Soldering of Aluminum

Information on the soldering of aluminum is presented in a new booklet by Reynolds Metals Co., Dept. PRD-6, Box 2346, Richmond 18, Va.

Newest addition to the Reynolds series of technical brochures, the reference includes data on soldering fluxes, irons and flames, and gives information on actual soldering methods such as hot plate, dip, furnace, friction, glass fiber brush and ultrasonic operations.

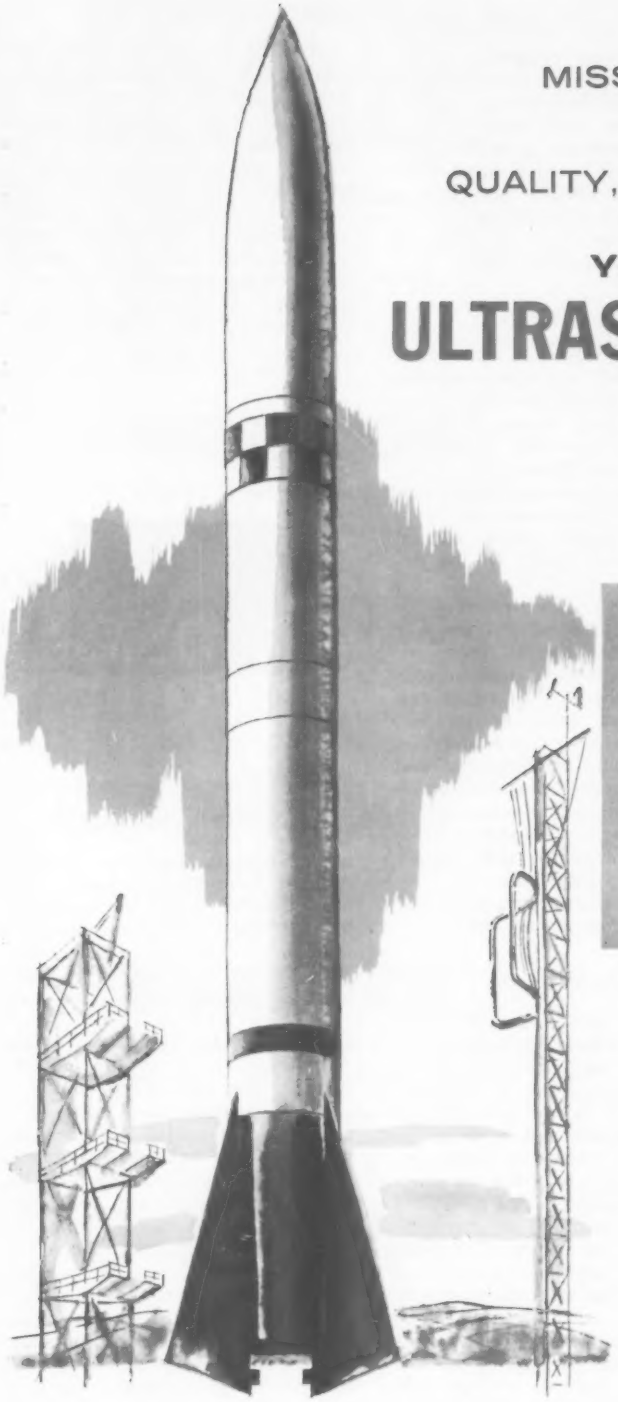
Types and properties of aluminum solders are explained, plus the corrosion of soldered joints and their performance in aluminum. Text is supported by diagrammatic illustrations.

For your free copy, circle No. 51 on Reader Information Card.

Strain-gage Selection

"How to Select a Strain Gage," a 24-page article comparing the characteristics of resistance strain gages made by eight U. S. manufacturers, is now available from Stein Engineering Services, 5602 E. Monte Rosa, Phoenix, Ariz. Specified in the article are selection criteria for various strain-gage properties under different operating conditions. The booklet is a reprint from Volume II, No. 1, *Strain Gage Readings*, the periodical devoted exclusively to strain gages, strain-gage transducers and associated instrumentation.

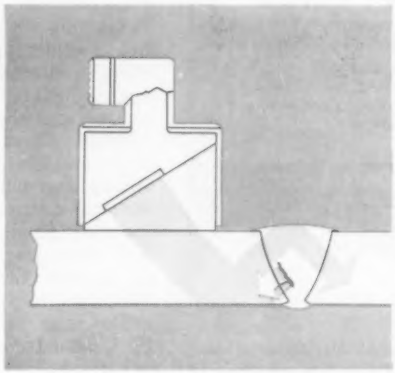
For your free copy, circle No. 52 on Reader Information Card.



MISSILES DEMAND
WELDMENTS OF HIGHEST
QUALITY, REGARDLESS OF COST–

YET LOW-COST
ULTRASONIC TESTING
IS USED!

This is because Ultrasonic Testing can locate defects in welds that are hidden to other inspection methods.



Sound beamed at an angle into the plate passes through a good weld but is reflected back from a void.

WHERE COSTS COUNT MOST
SPERRY REFLECTOSCOPE

provides down-to-earth answers on weldment quality for every industry. The Reflectoscope locates cracks, lack of fusion, incomplete penetration, fatigue failure, even in the thickest plate and deepest welds. Costs are low. For example, in a recent test of seam welds on a large pressure vessel, Reflectoscope inspection was one quarter the cost of other testing methods. And, there is no radiation hazard.

FOR INFORMATION ABOUT THIS INSPECTION TOOL, FILL OUT AND MAIL THE COUPON.

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For details, circle No. 29 on Reader Information Card

When You Weld Cast Iron
Select the Correct
Fuse-Well
CAST IRON WELDING RODS
OR ELECTRODES

FUSE-WELL NO. 11

FUSE-WELL No. 11, *Square*—Gray Cast Iron Welding Rod for Acetylene use in filling or building up new or worn castings producing machineable welds.

FUSE-WELL NO. 12

FUSE-WELL No. 12, *Round*—Has the same uses and analytical ingredients as Fuse-Well No. 11.

FUSE-WELL NO. 14 MOLY

FUSE-WELL No. 14, *Moly*—An Iron Base Rod with alloys added for finer grain structure and greater strength.

FUSE-WELL NO. 22

FUSE-WELL No. 22, *Electrode* — Light coated Rod to be used for AC or DC welding in the fabricating and repairing of cast iron castings.

THE CHICAGO HARDWARE FOUNDRY CO.
Weld Rod Division
NORTH CHICAGO, ILLINOIS

For details, circle No. 30 on Reader Information Card

Aluminum

The winter 1958-59 issue of the "Aluminum Bulletin" is now available from the Aluminum Assn., 420 Lexington Ave., New York 17, N. Y. Included in the 16-page, $5^1/_2$ x $8^1/_2$-in. booklet are articles describing Chrysler's use of aluminum in the automobile industry and the many applications of the metal on the farm.

For your free copy, circle No. 53 on Reader Information Card.

Aluminum Welding Wire

A new booklet, describing "Filler Wire Surface Quality in High Strength Aluminum Welding," is now available from the Dalweld Co., Inc., 11 Bertel Ave., Mount Vernon, N. Y. The booklet describes availabilities, sizes, tempers and additional data concerning aluminum welding wire.

For your free copy, circle No. 54 on Reader Information Card.

Copper-phosphorus Alloy

American Brazing Alloys Co., P. O. Box 11, Pelham, N. Y., has issued Data Sheet No. 155 to describe Phos Sil 0, a new copper-phosphorus alloy which does not require flux on copper-to-copper joints. It reportedly starts to melt at 1300° F and finds use on copper, brass, bronze and other alloys. The alloy conforms to AWS specification BCuP-2 and Federal specification QQB-00655a and has a tensile strength of 90,000 psi.

For your free copy, circle No. 55 on Reader Information Card.

Aluminum Mill Products

Copies of "Reynolds Aluminum Mill Products" are now available from Reynolds Metals Co., Dept. PRD-1, Box 2346, Richmond, Va.

Based on Reynolds' experience in making and fabricating aluminum, the brochure reportedly enables designers, engineers and buyers to pinpoint specific properties and apply them accurately to the desired end use.

Starting with a description of the light metal's classic advantages over other materials, the 18 pages include alloy and temper designations, fatigue and shearing strengths and various alloys available in foil, sheet and plate, wire, rod and bar, tubing and pipe and extruded and structural shapes. Fabricating and finishing techniques are summarized.

A bibliography provides a guide to related literature and movies available from Reynolds.

For your free copy, circle No. 56 on Reader Information Card.

Contour-sawing Machine

A 26-page catalog describing the "Pan-Arm" contour-sawing machine opens new vistas for fast, economical heavy machining and is available from the DoALL Co., Des Plaines, Ill. It is shown that feeding the cutting head while the work remains stationary removes the usual job size limitations, and gives the operator freedom of control. Straight-line cuts up to 17 ft long and intricate contour cuts are said to be quickly set up and accurately performed.

In order to show potential users the range and versatility of the "Pan-Arm," several of the new machining techniques that it has made possible are disclosed. These include the fabrication of large machinery and marine parts by cutting them from the solid. This reportedly takes less time with the "Pan-Arm" than procuring castings or forgings, and eliminates costly patterns and dies.

For your free copy, circle No. 57 on Reader Information Card.

Industrial Radiology

The 7th Supplement to the *Bibliography on Industrial Radiology* (1956–58) by H. R. Isenburger is available from St. John X-Ray Laboratory, Califon, N. J. This 27-page publication is intended to supplement the original 1943 work, *Industrial Radiology*, by St. John and Isenburger and includes added bibliographies introduced through the growing importance of radioisotopes. Copies are obtainable from the company at $4.00 each.

Filler Metals

Filler Metals for Joining, by Orville T. Barnett, assistant manager, Metals Research Division, Armour Research Foundation, Chicago, Ill. Hard-bound cover, 6 x 9 in., 244 pages. Includes 71 figures, 72 tables and 16-page index. Price $7.00. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. Available from the publisher or the AMERICAN WELDING SOCIETY, 33 W. 39th St., New York 17, N. Y.

Mr. Barnett's new book is a compact and useful guide to the novice in the welding industry as well as a valuable reference for the experienced individual. Basically, each of the first ten chapters, following a general introductory chapter, describes a single arc-welding electrode such as E6010 or a class of electrodes such as the iron-powder type. In each description, discussion applicable to the electrode or electrode class in question provides such information as mechanical properties, coverings, application, procedure, codes and proper current.

Other chapters are written on automatic welding wires for carbon or low-alloy steels, aluminum and aluminum alloys, copper and copper alloys, nickel and nickel-base alloys, surfacing, tungsten electrodes, brazing and soldering.

Survey Results

If you've kept up with your reading, you should now know that five points of especial interest have been developed by the survey requested by a leading advertising agency. Because these 5 points are especially interesting to future advertisers in the Welding Journal, we thought we'd stack them up together to give you a chance to compare them with any magazine in the welding field to determine where you can get the most from the advertising dollar.

1

Read Welding Journal regularly . . . **98%**

Proof of complete liaison between the editorial staff and the reader

2

Find Journal contents helpful . . . **98%**

Proof that W.J. contents are **basic** to the whole welding profession

3

Read ads in Journal . . . **87%**

Proof that Welding Journal readers are ever-alert for new products

4

Have bought products as result of reading Welding Journal . . . **49%** (!)

Proof of effectiveness of Journal for advertising any welding product or service

5

Have investigated new processes on basis of ads in Journal . . . **71%**

Proof that W.J. readers are alert, curious, show-me kind of people . . . the kind who are proud of their profession and their contribution to industrial progress. Can you afford to miss this market?

WELDING JOURNAL

Tempilstik°

*temperature indicating crayons**

**Also Tempil° Pellets and Tempilaq° (liquid form)*

***Tempilstik°*—a simple and accurate means of determining preheating and stress relieving temperatures in welding operations. Widely used in all heat treating—as well as in hundreds of other heat-dependent processes in industry. Available in 80 different temperature ratings from 113°F to 2500°F . . . $2.00 each.**

Send for *free* sample Tempil° Pellets. State temperature desired . . . Sorry, no sample Tempilstiks°.

Most industrial and welding supply houses carry Tempilstiks° . . . If yours does not, write for information to:

ACCESSORIES DIVISION

Tempil° CORPORATION

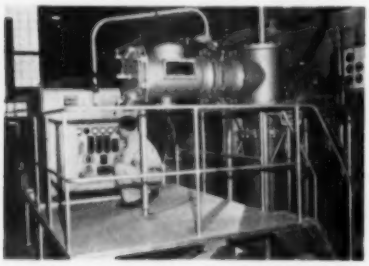
132 West 22nd St., New York 11, N. Y.

For details, circle No. 31 on Reader Information Card

New Products

Electron-beam Welding Machine

A new electron-beam welding machine joins reactive and high-melting-point metals used extensively in critical missile and atomic-reactor applications has been designed and constructed by Air Reduction Co.'s Central Research Laboratories, Murray Hill, N. J. This new unit applies a high-intensity electron beam to weld beryllium, molybdenum, tantalum, zirconium, hafnium and all other exotic metals which before this could not be welded satisfactorily,



or were very difficult to weld by conventional techniques. Application of the process will require custom-built equipment for specific jobs.

The electron beam bombards the materials to be welded in a very high-vacuum chamber.

The use of a high vacuum makes it impossible for the metals to be contaminated by the atmosphere during the welding process, a necessary condition for the effective welding of reactive metals. In fact, many of the contaminators that might be present in the original workpieces are removed during the welding process.

For details, circle No. 58 on Reader Information Card.

X-ray Film Processor

According to the X-Ray Division, Eastman Kodak Co., Rochester 4, N. Y., processing industrial radiographs automatically is now possible with the new "Kodak X-Omat Processor." It delivers a

dry industrial radiograph in 13 min, an hour faster than most hand-operated methods now in use.

Mechanical advantages include self-threading and a continuous transport using a series of precision rollers to convey the film through the processing cycle. Accepting continuous lengths of roll X-ray film up to 17 in. wide, the "X-Omat" can also process several narrower strips side-by-side. This is a time saver in handling 70-mm strips of X-ray film used in weld inspection of pipe lines, missile shells and various pressure vessels.

Chemical advances pioneered for the "X-Omat" processor at Kodak's research laboratories include new chemicals which speed up the processing cycle. They provide for dry films in less than two minutes after washing, and reportedly maintain uniform, high-quality radiographic results.

For details, circle No. 59 on Reader Information Card.

Arc-welding Machines

The Lincoln Electric Co., Cleveland 17, Ohio, has announced a new line of industrial arc-welding machines.

The new units, called the "TM" Idealarc, are available either as a-c transformer or combination a-c and d-c rectifier welding machines. They have a mechanical, movable core-reactor type of current control and are made in NEMA rated 300, 400, 500 and 650 amp sizes.

In addition to the choice between

ac and ac/dc, the user has many optional features from which to select. Depending on the requirements of the application, he may choose remote control of current and polarity, a low-voltage contactor that reduces open-circuit voltage when the machine is on but not welding, a line contactor with overload protection and either a line- or 115-v pushbutton, an arc booster that provides a current surge during arc striking, or power-factor correction condensers. All optional features mount inside the machine.

Operating characteristics of the new machine are said to represent an improvement in machines of this type due to new electrical circuitry and construction. The machines have a 73-v open-circuit voltage, yet produce a stable arc with low a-c amperage and difficult-to-use electrodes.

For details, circle No. 60 on Reader Information Card.

D-c Rectifier Welding Machine

Miller Electric Mfg. Co., Inc., Appleton, Wis., announces a new unit which delivers 1000 amp of dc at 40 v on 100% duty cycle. Used with 3-phase power lines, the SR-1000-A1 features the new Miller completely sealed semimetallic rectifier.

Single current range adjusts output from minimum of 200 amp to

Lincoln

WELDYNAMICS

NEWS ABOUT ARC WELDING AT WORK CUTTING COSTS

Oil well pump chain housing is positioned for flat welding with Jetweld. Welding speed is doubled.

OIL FIELD PUMPING UNITS NOW WELDED TWICE AS FAST

Doubling welding shop production without increasing their investment in labor or machines was accomplished by the Parkersburg Rig and Reel Company at Coffeyville, Kansas.

This firm manufactures oil field pumping units. The complete structure of these units is welded and varies in size depending upon the requirements of the well on which they are to work. Bases are fabricated from as small as 8″ 17 lb. beams to as large as 14″ 68 lb. beams. One exceptionally large unit used a 36″ 210 lb. member for the walking beam.

Under the supervision of Jess Kern, Plant Manager and Sammy Doss, Welding Foreman, tests were conducted in the Parkersburg shop in an effort to increase welding efficiency.

A Lincoln welding engineer, Robert Clipsham, surveyed the welding operation. He studied the procedures used and conducted tests with various electrodes and equipment.

The survey indicated that with minor positioning changes almost every weld could be made with a faster, easier-operating iron-powder electrode.

Parkersburg is now using Jetweld 1 electrodes almost exclusively. Mr. Doss says, "Jetweld is twice as fast as the conventional electrodes we were using. It gives us better looking welds, mileage per rod is greater, and weld cleaning is much easier and faster."

Completed chain housing mounted on base fabricated from I beams.

Sammy Doss, Welding Foreman at Parkersburg Rig and Reel has switched to Jetweld almost exclusively.

For help with welding procedures and cost reduction ideas call your Lincoln welding engineer today.

NEW WELDER TAILORED TO YOUR NEEDS

The new Lincoln Idealarc "TM" welder has been designed to meet the needs of any shop.

The key to the "TM" model's versatility is a wide range of options that expand the uses for the machine.

These new Idealarcs are available in 300, 400, 500 and 650 amp sizes.

Bulletin 4607.1 has all the details. A copy may be obtained by writing The Lincoln Electric Company.

The LINCOLN ELECTRIC CO.
Dept. 1954 • Cleveland 17, Ohio
The World's Largest Manufacturer of Arc Welding Equipment

For details, circle No. 32 on Reader Information Card

maximum of 1600. This model is recommended for heavy submerged-arc welding, the plasma-jet process, air carbon-arc gouging and some electric-furnace applications.

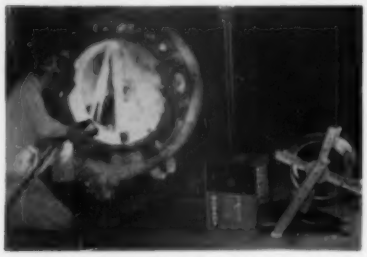
For details, circle No. 61 on Reader Information Card.

Semiautomatic Welding Machine

A portable semiautomatic welding machine designed for either open-arc hard surfacing or submerged-arc welding has been announced by Hobart Bros. Co., Troy, Ohio.

Known as Handomatic, the unit features a universal semiautomatic wire feeder designed for hard surfacing, buildup and mild-steel welding using tubular (fabricated) wires or solid wires, open-arc or submerged-arc processes.

It may be connected to almost any welding machine, either ac or dc.



A single rheostat controls the wire-feed speed. Electrical components are protected by steel cabinets. Cooling is provided by openings and side panel louvers. The wire-feed mechanism and drive plate are accessible by a hinged door. To remove the wire-reel assembly, it is necessary to remove only four bolts securing it to the base.

Feed rolls, pressure rolls and current tips are available for $^{5}/_{64}$- and $^{3}/_{32}$-in. solid hard wire; and $^{3}/_{32}$- and $^{7}/_{64}$-in. tubular wire. The unit is designed for use with continuous current up to 500 amp using the flux-type or open-arc gun. The flux hopper holds 5 lb of flux.

The wire-speed range, at nominal 30 v, is 60 to 260 ipm; an optional gearbox provides 90 to 460 ipm at nominal 30 v.

For details, circle No. 62 on Reader Information Card.

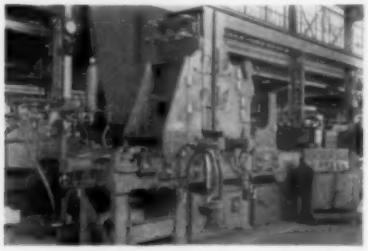
Magnesium Solder

EutecRod 1909, a self-fluxing solder-type alloy for joining magnesium, has been introduced by Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y. The manufacturer reports that this alloy melts at 350° F and is useful in building up, filling and sealing castings, wrought forms and extruded shapes. The alloy is also recommended for joining aluminum to aluminum provided that Eutector 1909 flux is employed. In instances when aluminum is to be joined to copper and steel alloys, the manufacturer suggests the use of Eutector Flux 1909B.

For details, circle No. 63 on Reader Information Card.

Flash-butt Welding Machine

Sciaky Bros., Inc., 4915 W. 67th St., Chicago 38, Ill., announce the new design of a BPW. 3—400H flash-butt type welding machine in principle for the continuous end-to-end fastening of flat wide strip stock.



This welding machine, often referred to as a skelp welder, is used in various mill and process operations. Its most common use is associated with plating, pickling, stamping, forming and other operations where a continuous feed of strip stock is essential.

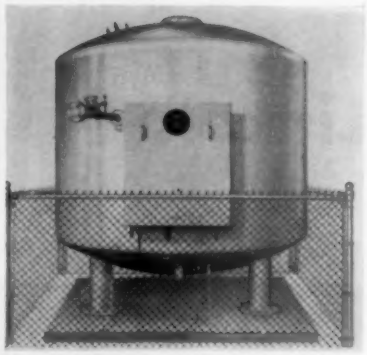
This Sciaky BPW.3—400H machine is designed for flash-butt welding hot-rolled, low-carbon steel, ranging from 0.060 to 0.200 in. in thickness and from 12 to 22 in. in width, or, a maximum capacity of 4.5 sq in. cross-sectional area of mild steel, and 2.6 sq in. cross-sectional area of stainless steel.

The upset force is adjusted to a maximum of 90,000 lb, while clamping force is adjustable to a maximum of 135,000 lb. Maximum platen opening is 8 in., and flashing action is accomplished by means of the right-hand platen. Pressure lubrication can be provided.

For details, circle No. 64 on Reader Information Card.

Atmospheric Gas System

A new Liqua-Guard System has been developed by Cambridge Corp., subsidiary of Carrier Corp., 2 Industrial Ave., Lowell, Mass., in the storing and handling of atmospheric gases.



The basic components of the system include "Liqua-Guard" customer stations for installation at the user's site, semitrailers, bulk-storage units, delivery trucks, pumps and vaporizers.

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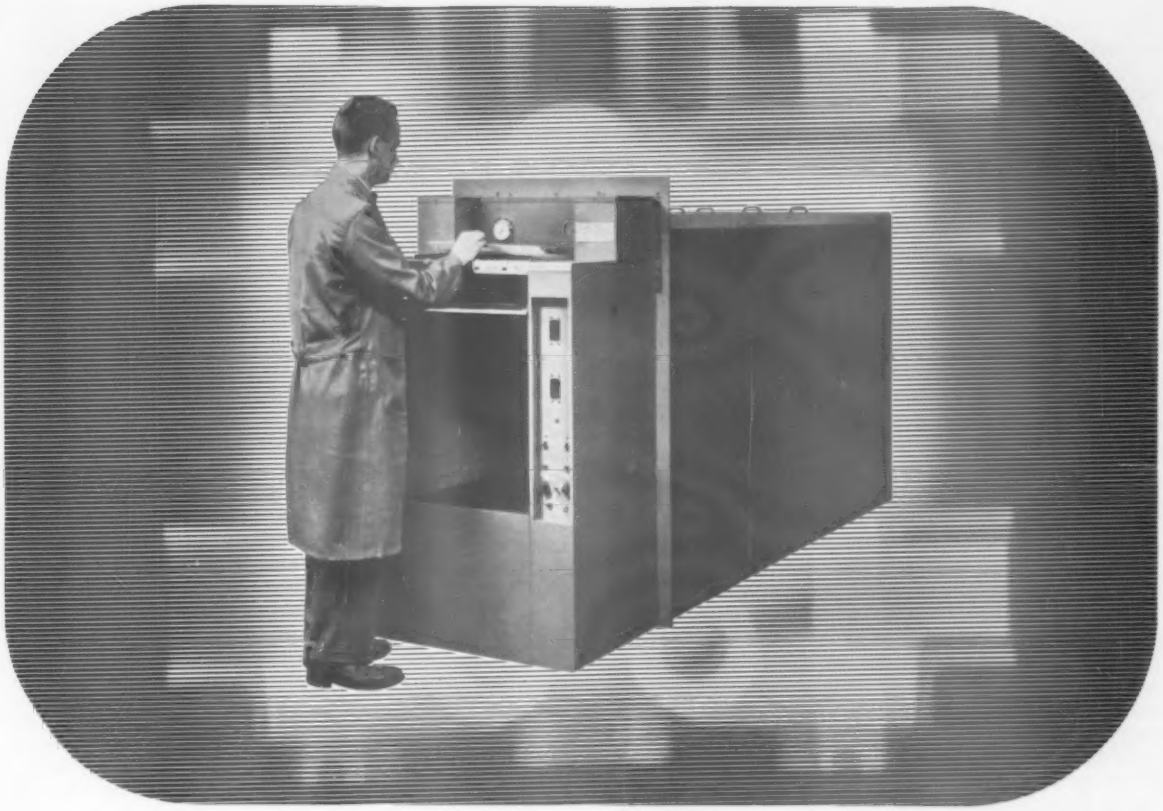
Turning Rolls

Aronson Machine Co., Arcade, N. Y., announces an addition to their current line of equipment of turning rolls for automatic and manual welding of cylindrical vessels, the models WSD400S1G and WSD400S2G. These rolls, when

used in conjunction with each other, are designed for rotation of heavy-wall vessels for welding or cladding such as encountered in nuclear-reactor projects. Hardsurfaced 30-in. OD, precision-machined wheels, with 7-in. faces, reportedly support in excess of 400-ton load capacity. These rolls provide four selective speed ranges from 4 to 80 ipm for smooth positioning of



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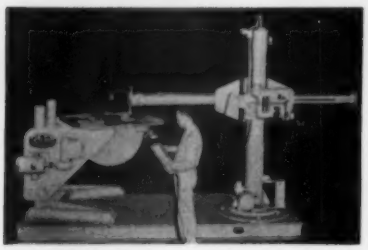
Fixture and Positioner

The Webb Corp., Webb City, Mo., has introduced two new products, the Webb 360-deg Mast and Boom Fixture and the Webb 6000 Pound Positioner.



The fixture reportedly permits longitudinal welding as well as welding-head positioning. Provision is made for internal wiring, while the hardened and ground steel ways are said to be reversible and interchangeable. Standard equipment includes overload and undervoltage protection, 110-v operator's station and 4-direction limit switch.

The positioner features a work table mounted on a large ball race. Vertically adjustable, the table also has power tilt accomplished with a magnetic brake motor through a double-reduction gear box.

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Magnetic-particle Inspection

The "Detectascope" unit, a portable magnetic-inspection device which detects surface and subsurface discontinuities in ferrous magnetic materials, has been introduced by Ferro Machine & Tool Corp., 5514 W. Washington St., Indianapolis, Ind.

The unit consists of an electromagnet, a black light hood, black light, transformer, pump for agitation, tank, demagnetizer and auto transformer. It operates from 110-v, 60-cycle, single-phase current, and reportedly has a d-c magnetizing output of 5200 amp from a 1.2-amp input. The unit is of metal construction measuring 52¾ in. high, 36 in. from left to right, 18½ in. front to back and weighs approximately 150 lb.

The "Detectascope" may be used with either fluorescent or non-fluorescent solution anywhere that a 110-v outlet is available.

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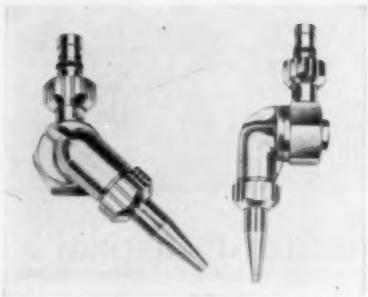
Beveling Attachment

A beveling attachment that enables a torch operator to change the cutting angle without extinguishing the flame has been introduced by Smith Welding Equipment Corp., 2633 Fourth St., S.E., Minneapolis 14, Minn.



Designed principally for bevel cutting with a machine torch, Smith's new SC290 attachment is calibrated in increments of 15 to 90 deg on each side of vertical to permit cuts at most angles. The absence of stops on the swivel member also permits reverse beveling.

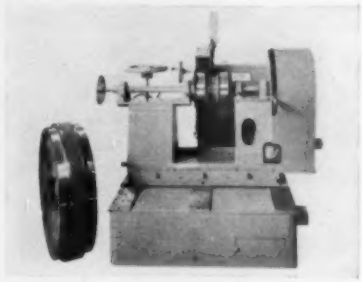
Adaptable to standard cutting machines equipped with Smith's torches, the unit weighs 19¼ oz without the tip. In vertical position, it measures 5¼ in. from tip end to the torch.

For details, circle No. 69 on Reader Information Card.

Grinding Unit

A new grinder, designed specifically for finishing crawler-tractor rollers and idlers, is now available from L and B Welding Equipment, Inc., 2424 6th St., Berkeley, Calif.

The major features of this machine are said to be its ability to handle any size roller and idler, the cross-feed for moving the faces across the grinding-wheel surface, the built-in dust fan and collector, a 15-hp motor for driving the grinding wheel, a 1-hp motor and adjusting optimount for rotating the rollers and a special long-wearing grinding stone.



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Noncorrosive Flux

A new hydrazine flux that is said to leave no rosin residue, is noncorrosive, nonhygroscopic and permits prefluxing is now available from Fairmount Chemical Co., Inc., 136 Liberty St., New York 6, N. Y. The new nonacid flux, designed for use in soldering electrical and electronic equipment, eliminates residue removal and insures corrosion-free joints.

According to the manufacturer, Hydrazine Flux vaporizes completely in the heat of soldering, and joints made with the flux will not corrode.

The following metal surfaces can be soft-soldered with Hydrazine Flux: copper, brass, hot tin dipped, hot solder dipped, tin plate, solder plate, copper plate, cadmium plate, zinc, silver plate, beryllium copper and nickel-plated brass. It can be used with the following systems: common solders of tin-lead; tin-lead-silver; tin-antimony; tin-silver; certain fusible alloys containing tin, lead, cadmium, bismuth, antimony, indium; pure tin; pure lead for bonding to copper.

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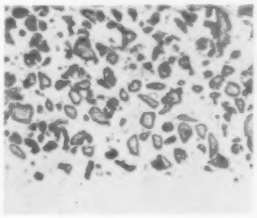

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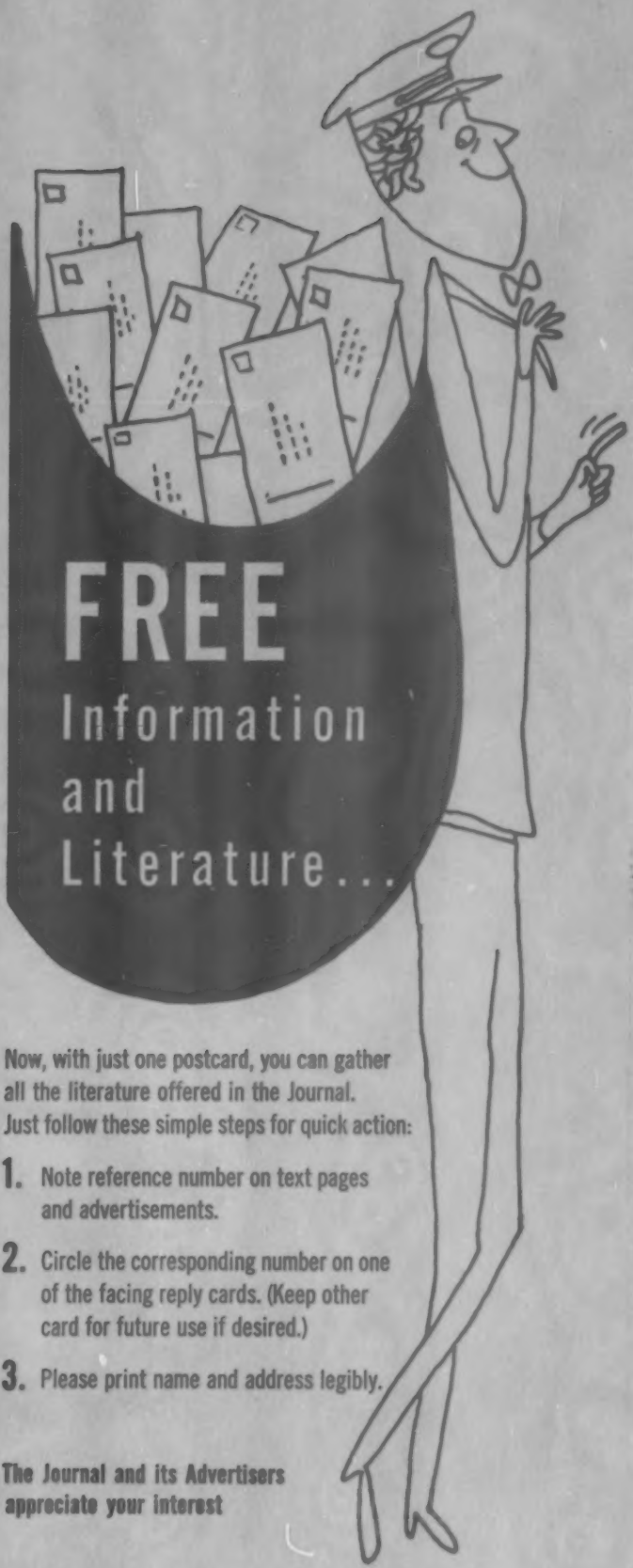

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SUPPLEMENT TO THE WELDING JOURNAL, MAY 1959

Normalization Procedures for NRL Drop-Weight Test

Paper describes nil-ductility transition concepts in great detail and rigorous procedures which will insure that the same parameter will be measured regardless of specimen size

BY P. P. PUZAK AND A. J. BABECK

ABSTRACT. The development of standard test conditions in the NRL drop-weight test and the effectiveness of those conditions are discussed. It is shown that the 0.3-in. anvil stop permits wide latitude in nominal test procedures without materially affecting the nil-ductility transition (NDT) results obtained in the standard test.

Test conditions established for $3^1/_2$- × 14- × 1-in. specimens (0.3-in. anvil stop, and a 12-in. span) have been validated by numerous correlations with service-failure steels. As a result, these test conditions are considered the "reference-standard" test conditions. Strain conditions developed on the tensile surface of the standard test specimen must be reasonably duplicated in nonstandard specimens before comparable NDT temperatures are obtained.

Test data for 90 steels are presented, and procedures for a determination of surface strain in the drop-weight test are explained in terms of the weld-crack opening developed in specimens tested at temperatures approximately 100° F above the NDT temperature. These procedures, or any other valid measure of surface strains, can be utilized to establish the test conditions necessary to achieve a normalization of variables involving odd-size specimens. Normalized test conditions employed for specimens which vary from $^1/_2$ to $7^5/_8$ in. in thickness are shown to result in NDT determinations which duplicate within experimental and engineering requirements the NDT of a given steel determined in the reference-standard test.

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Introduction

The NRL drop-weight test was developed on the basis of requiring a given steel to exhibit a small amount of plastic deformation in the presence of a cleavage crack. In the original studies,[1] the amount of plastic deformation was initially limited so that only 1 to 2% lateral contraction was developed across the $3^1/_2$-in. width of a specimen which did not break. This limit was achieved on open-anvil tests by an adjustment in the weight and drop conditions to deliver a force slightly greater than that required to develop a visible crack in a mechanically notched crack-starter weld deposit. This procedure required the testing of several specimens in order to establish the minimum impact energy which would just crack the brittle weld deposit. By definition, the highest temperature at which a given steel broke instead of deforming the small amount required in the test was termed the nil-ductility transition (NDT) temperature. Thus, the drop-weight test represents a simple laboratory determination of fracture performance in steels at a "technical" but finite level of ductility.

A detailed description of the NRL drop-weight test has previously been given; and for specific information concerning the equipment, preparation of specimens and general testing procedures, the reader is referred to the published literature,[2, 3, 4] During the past two years, the drop-weight test has found increasing application in research and alloy-development programs with materials covering a wide range of thicknesses. This situation has made it mandatory to describe NDT concepts in greater detail and to indicate rigorous procedures which will insure that the same parameter (i.e., ductility in the presence of a sharp notch) will be measured regardless of specimen size.

The simple procedures recommended for the preparation of drop-weight specimens, which do not allow for effects such as warpage between several specimens cut from one steel plate, can easily result in slight variations in dimensions or flatness. Therefore, in order to ensure that these nominal variations between specimens do not significantly affect the reproducibility of the test, the open-anvil procedures were modified by the incorporation of a central anvil stop. From empirical studies conducted with $^3/_4$- to 1-in. thick steels, it was established that deflection so as to make contact with a 0.3-in. anvil stop produced essentially the same amount of plastic deformation as that obtained in

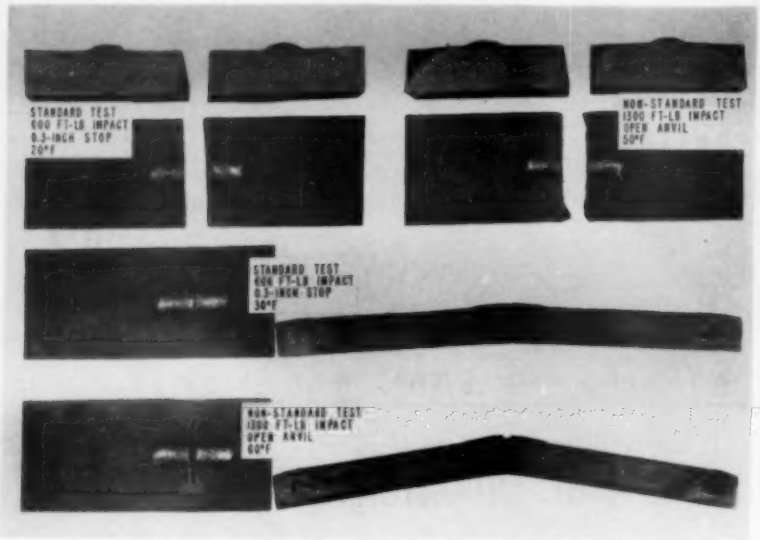

Fig. 1—Drop-weight test specimens of steel No. 62 tested under standard and nonstandard conditions to show increasing ductility with increasing temperature

Fig. 2—Heavy-section drop-weight equipment illustrating loading technique and representative examples of "break" and "no break" tests with 6-in. thick drop-weight specimens

Table 1—Standard and Nonstandard Drop-weight Test Results for Steel No. 62 NDT Temperature, 20° F

Impact, ft-lb	Anvil stop	Break (X) or No Break (O) at Test Temperature —40° F	0° F	10° F	20° F	30° F	40° F	50° F	60° F	Remarks
250	0.3 in.	O	O	O	O	..	..	..	..	No weld crack
300	0.3 in.	..	X	X	O	O	..	..	..	Specimens did not contact stop; broke at 10° F below NDT
400	0.3 in.	..	..	..	XX	OO	..	..	..	Specimens did not contact stop; NDT not changed
500	0.3 in.	..	..	..	XX	OO	..	..	..	Specimens did not contact stop; NDT not changed
600	0.3 in.	..	..	..	XX	OOO	...	..	..	Standard, NDT = 20° F
950	0.3 in.	..	..	..	X	O	O	O	..	NDT not changed
1300	0.3 in.	..	..	..	X	XO	OO	O	..	Specimens broke at 10° F above NDT
600	Open	..	..	..	X	O	O	..	..	NDT not changed
950	Open	..	..	..	X	X	O	O	..	Specimens broke at 10° F above NDT
1300	Open	..	..	..	X	X	X	X	O	Specimens broke at 30° F above NDT

minimum-impact-energy, open-anvil tests.* Accordingly, the 0.3-in. anvil stop was taken as standard for drop-weight tests of $3^1/_2$- × 14-in. specimens up to 1 in. thick.

The use of a 0.3-in. anvil stop for standard test determinations of the NDT temperature subsequently was found to permit considerable latitude in nominal test procedures. As the result of inertia effects, increasing impact energies were found to develop moderately higher deformations for any given steel tested on the 0.3-in. anvil stop; however, the NDT of the steel was not significantly changed. Table 1 gives results of standard (0.3-in. anvil stop) and nonstandard (no anvil stop employed) drop-weight tests for steel No. 62, a 1-in. thick semi-killed steel having an NDT of 20° F. It should be recognized that the general engineering procedures and instrumentation employed for drop-weight tests restrict the accuracy of NDT temperatures to ±10° F. The specimens did not break at any test temperature when the impact energies (250 ft-lb) were not sufficient to produce a weld crack. With the minimum impact energy necessary to produce a weld crack (300 ft-lb) the specimens did not break at the NDT temperature, but did break at temperatures only 10° F below the NDT. Impact energies of approximately 600 ft-lb were required for standard NDT determinations in which the nonbroken specimens contacted the anvil stop. Moderately lower (400 ft-lb) or higher (950 ft-lb) impact energies did not change the standard NDT temperature for this steel. Impact energies (1300 ft-lb) greatly in excess of the minimum required for specimens to make contact with the 0.3-in. anvil stop resulted in the breaking of occasional specimens at test temperatures which were 10° F higher than the NDT.

In nonstandard tests, the use of excessive impact energies obviously permits the development of greater surface strains. Table 1 indicates that in open-anvil tests, specimens could be broken at temperatures of 30° F or more above the NDT. Visual examination of the test specimens, however, reveals significant differences in ductility characteristics (Fig. 1). The standard test specimens are characterized by square fractures at the NDT temperature (20° F), and by the absence of visible edge contractions at 30° F. The nonstandard test specimens, on the other hand, develop heavy shear-lip formations when broken at 50° F and easily visible evidences of ductility at 60° F.

The fracture performance exhibited by steel No. 62 is considered to be representative of that displayed by conventional structural steels.

* This was described[2] in terms of a 3-deg bend required just to crack the weld and a 5-deg bend to contact the stop. These were the average residual bend measurements made on specimens tested on a 0.3-in. anvil stop and, in fact, represent bending through a static angle of 2 deg 52 min. The additional bending developed in the specimen is the result of inertia effects and partial acceptance of the weld crack by the plate.

Additional studies have been conducted, and similar results have been obtained for other medium-carbon and high-tensile-strength steels. Thus, providing contact is made with the 0.3-in. anvil stop, the impacting energy may be varied over a reasonable range without affecting the NDT results of the standard drop-weight test by more than a few degrees (±10° F). In addition, at test temperatures only slightly below the NDT of a given steel, fractures are generally obtained with impact energies less than the minimum required to contact the stop. This indicates that complete fracture is obtained at an early stage in the drop-weight test. If the specimen does not break in the standard test,* contact of the specimen with the stop effectively ends the test.

Reference-standard Drop-Weight Test

The 0.3-in. anvil stop was used for drop-weight test studies of ship-fracture and similar steels.[3] The NDT results obtained correlated not only with ship-service history, but also with Charpy V test data established by National Bureau of Standards' investigations of ship-fracture plates.[5] The empirical correlations with ship-service history indicated that the NDT, as measured in the standard drop-weight test, was significant and represented the highest temperature at which a steel was potentially able to initiate brittle fracture in conventional structural applications.

Further validation of the significance of NDT was obtained in subsequent tests of 1-in. thick drop-weight specimens cut from two heavy-section A302 pressure-vessel service failures.[6, 7] These service failures both occurred at a temperature between 55 and 60° F, and involved a 3-in. thick vessel which failed during hydrostatic proof testing and a $2\,^{9}/_{16}$-in. thick vessel which failed during fabrication as the result of residual welding stresses developed during the welding of the manway reinforcement. Drop-weight tests of 1- × $3\,^{1}/_{2}$- × 14-in. specimens cut from these thick steels were conducted on the 0.3-in. anvil stop, and an NDT of 70° F for the first and 100° F for the second failed vessel indicated correlation of NDT with pressure-vessel service. In addition, Charpy V tests on steel from the second failed vessel were found to corroborate the predictions made previously from drop-weight tests of similar steels concerning the possible initiation of brittle fractures at temperatures corresponding to the 20 ft-lb Charpy V temperature.

Additional nonship structural failures have similarly been drop-weight tested and have demonstrated consistent correlation with service performance by always exhibiting NDT temperatures above the respective failure temperatures.[8] Accordingly, the 1- × $3\,^{1}/_{2}$- × 14-in. specimen tested on a 12-in. span with a 0.3-in. anvil stop is considered to be the reference-standard drop-weight test. NDT determinations for specimens of greatly different dimensions must, therefore, be conducted under surface strain conditions which are compatible with those developed in the reference-standard test.

During the early drop-weight testing programs, problems involving testing variables were not encountered because tests were conducted only with conventional materials of approximately 1-in. thickness. Thin-plate structural materials were not considered for drop-weight tests since they are not generally involved in brittle service failures. On the other hand, laboratory fracture tests of full-thickness heavy-section materials were un-

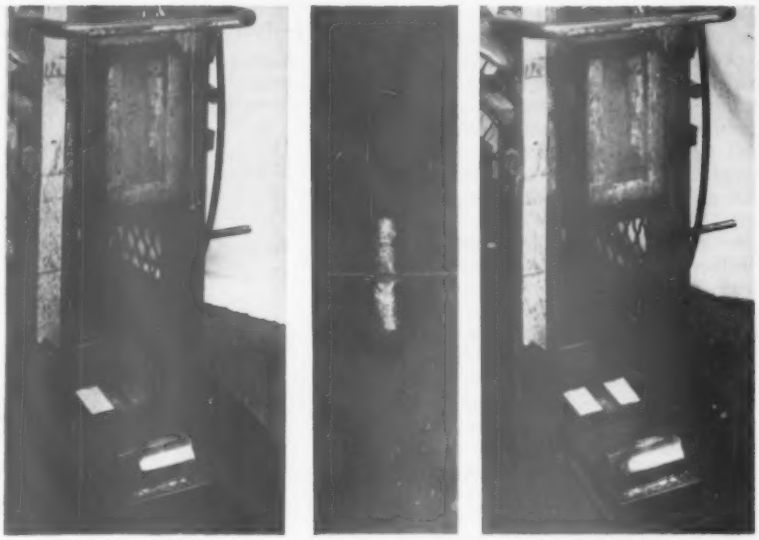

Fig. 3—Procedure employed to indicate contact of specimen with anvil stop: (left) the application of masking tape to anvil stop surfaces; (center) the scribing of wax-pencil lines on the tensile side of the specimen contiguous to the notch; and (right) the transfer of the wax lines to the tape when contact of the specimen with the stop is made

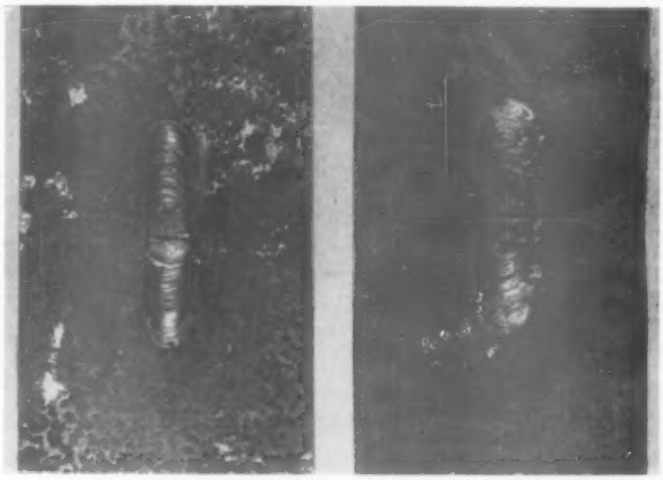

Fig. 4—Variation of weld-crack opening with temperature: (left) specimen tested approximately 100° F above NDT; (right) specimen from same plate tested with a similar impact energy at near NDT temperature

* Generally, broken specimens are fractured completely across the tensile surface. Partial breaks (fracture completely across one-half the specimen) are considered equivalent to broken specimens because results have shown that full breaks are invariably obtained in additional samples of the same steel tested at the same temperature.

heard of, and NDT determinations of thick steels were initially based only upon results obtained with 1-in. thick standard test specimens cut from them. The problem of determining the NDT temperature in full-thickness specimens was first studied with 6-in. thick steels using an open anvil test and energy impacts just sufficient to produce visible cracks in the crack-starter weld. Subsequent tests with progressively heavier drop weights (240 to 2000 lb) have been employed for NDT evaluations of full-thickness specimens varying from $1^3/_4$ to $7^5/_8$ in. in thickness. The effectiveness of the crack-starter weld approach was such that the only limitations appeared to be those related to the size of the drop-weight equipment. Figure 2 illustrates the present heavy-section equipment, the foundations of which required a separate spring-suspension mounting of a 30-ton mass.

As originally conceived, drop-weight test procedures were based upon the normalization of variables between different specimens. For example, the impacting energies employed in reference-standard drop-weight tests of ship-steel specimens (35,000 psi yield strength) and of HY80 steel specimens (80,000 to 95,000 psi yield strength) are adjusted so that each specimen is required to make contact with the 0.3-in. anvil stop. Thus, the variable of strength differences between these steels is eliminated, and the NDT for each steel is determined at a similar reference index.

In a similar manner, a normalization of geometrical parameters is required to permit the testing of specimens which differ greatly in size from the original reference-standard specimen ($1 \times 3^1/_2 \times 14$ in.). In order to avoid confusion and prevent misuse of the test, or of the term NDT, this report is aimed at presenting the normalization procedures required for drop-weight testing of any given steel, irrespective of variations in specimen dimensions, strength of steel, etc. For this purpose, the test data obtained with 90 steels, Table 2, over half of which were tested in two or more specimen sizes, will be used to illustrate the techniques employed at NRL to obtain normalization procedures for drop-weight tests.

Normalization Procedures for $^1/_2$- to $1^1/_2$-In. Thick Steels

Normalization procedures are aimed at the measurement of the NDT temperature of a given steel. For reference purposes, the normalization index for drop-weight tests is taken to be the surface strain developed in the specimen during the test. The latitude in procedures which is afforded by the use of the anvil stop indicates that the significant normalization index should be the total deformation developed in the specimen at the moment contact is made with the anvil stop. Figure 3 indicates the procedures employed at NRL to determine whether the drop-weight specimen does contact the anvil stop. These precautions have been taken in all drop-weight tests conducted by NRL after it was discovered that some 1-in. thick, quenched and tempered, high-strength alloy steels did not develop a weld crack in tests with the original equipment (60-lb weight).

Although established empirically, test conditions for the reference-standard specimens have been fully validated by numerous correlations with ship- and nonship-service failures. Accordingly, normalization limits are based upon the level of deformation which is developed in drop-weight tests of reference-standard specimens. Different size specimens can be readily cut from the same steel and tests conducted under conditions involving different test spans and anvil stops. NDT determinations made with different size specimens, however, can be considered valid for comparison purposes only when the relative index of strain developed in a given size specimen falls within the normalization limits established for the reference-standard test.

The amount of surface strain de-

Table 2—Test Data of Normalization Study Steels

Steel No.	Original thickness, in.	Steel type	Chemical Composition, % C	Mn	Si	P	S	Other
1	1	SK	0.16	0.48	0.10	0.010	0.025	..
2	$1^1/_4$	SK	0.23	0.45	0.10	0.010	0.032	..
3	2	A212	0.28	0.76	0.22	0.005	0.026	..
4	4	A212	0.27	0.67	0.25	0.030	0.027	..
5	1	HTS	0.16	1.27	0.23	0.011	0.028	..
6	1	HTS	0.17	1.18	0.31	0.023	0.026	0.06 V
7	1	HTS	0.15	1.12	0.29	0.013	0.027	0.05 V
8	1	HTS	0.13	1.06	0.25	0.015	0.021	0.05 V
9	1	HTS	0.18	1.09	0.29	0.008	0.025	0.04 V
10	1	HTS	0.15	1.13	0.23	0.011	0.026	0.06 V
11	2	A201	0.16	0.62	0.24	0.010	0.026	..
12	3	A201	0.20	0.62	0.24	0.029	0.026	..
13	4	A302	0.22	1.37	0.30	0.015	0.011	..
14	1	HY80	0.15	0.26	0.26	0.008	0.029	2.21 Ni, 1.00 Cr, 0.23 Mo
15	1	HY80	0.16	0.23	0.19	0.011	0.028	2.33 Ni, 0.89 Cr, 0.25 Mo
16	$^1/_2$	HTS	0.12	1.00	0.19	0.020	0.024	0.06 V
17	$^7/_8$	HTS	0.13	1.13	0.29	0.020	0.032	0.10 V
18	$^7/_8$	HTS	0.17	1.28	0.31	0.021	0.022	0.04 V
19	$^1/_2$	SK	0.19	0.42	0.03	0.010	0.051	..
20	$^3/_4$	ABS-B	0.15	1.05	0.053	0.011	[a]	..
21	$^3/_4$	ABS-B	0.16	0.94	0.043	0.010	[a]	..
22	$^3/_4$	ABS-B	0.15	0.93	0.049	0.009	[a]	..
23	$^3/_4$	ABS-B	0.18	1.02	0.045	0.012	[a]	..
24	$^3/_4$	ABS-B	0.18	1.04	0.045	0.012	[a]	..
25	$^3/_4$	ABS-B	0.18	0.95	0.075	0.011	[a]	..
26	$^3/_4$	ABS-B	0.18	0.96	0.069	0.011	[a]	..
27	$^3/_4$	ABS-B	0.19	0.96	0.62	0.011	[a]	..
28	$^3/_4$	ABS-B	0.18	0.71	0.02	0.012	0.027	..
29	$^3/_4$	HTS	0.17	1.30	0.35	0.012	0.040	0.05 V
30	$^3/_4$	HTS	0.14	1.30	0.31	0.013	0.026	0.05 V
31	$^3/_4$	HTS	0.16	1.24	0.31	0.011	0.020	0.04 V
32	$^3/_4$	HTS	0.17	1.13	0.28	0.012	0.019	0.04 V
33	$^3/_4$	STS	0.27	0.29	0.24	0.005	0.020	3.08 Ni, 1.17 Cr
34	$^7/_8$	HTS	0.20	1.21	0.25	0.013	0.020	0.06 V
35	$^7/_8$	HTS	0.15	0.95	0.27	0.018	0.030	0.09 V
36	$^7/_8$	HTS	0.14	1.10	0.25	0.020	0.030	0.10 V
37	$^7/_8$	HTS	0.15	1.09	0.27	0.021	0.034	0.09 V
38	$1^1/_4$	SK[b]	0.10	1.42	0.03	0.014	0.024	..
39	$1^1/_4$	SK[b]	0.18	1.33	0.02	0.012	0.023	..
40	$1^1/_4$	ABS-C	0.16	0.73	0.23	0.011	[a]	..
41	$1^1/_4$	ABS-C	0.16	0.73	0.22	0.011	[a]	..
42	$1^1/_4$	ABS-C	0.15	0.68	0.23	0.010	[a]	..
43	$1^1/_4$	ABS-C	0.14	0.66	0.21	0.010	[a]	..
44	$1^1/_4$	ABS-C	0.16	0.73	0.21	0.021	[a]	..
45	$1^1/_4$	ABS-C	0.15	0.73	0.23	0.020	[a]	..

[a] Not determined.
[b] Semikilled, low-carbon, high-manganese experimental heats.

Steel No.	Original thickness, in.	Steel type	Chemical Composition, % C	Mn	Si	P	S	Other
46	1 1/4	ABS-C	0.16	0.74	0.26	0.013	[a]	..
47	1 1/4	ABS-C	0.15	0.73	0.23	0.031	[a]	..
48	1 1/4	ABS-C	0.16	0.79	0.31	0.014	[a]	..
49	1 1/4	ABS-C	0.16	0.78	0.30	0.013	[a]	..
50	1 1/4	ABS-C	0.17	0.72	0.28	0.015	[a]	..
51	4 1/2	A212	0.27	0.70	0.20	0.016	0.026	..
52	4 1/2	A212	0.26	0.80	0.22	0.016	0.028	..
53	1 1/2	HTS	0.17	1.03	0.23	0.011	0.046	0.01 V
54	1 1/4	SK[b]	0.19	1.33	0.03	0.014	0.027	..
55	1 1/2	SK[b]	0.15	1.28	0.03	0.020	0.027	..
56	1 1/2	SK[b]	0.16	1.28	0.03	0.013	0.024	..
57	1 1/2	SK[b]	0.19	1.61	0.03	0.013	0.034	..
58	3/4	SK[b]	0.11	1.25	0.03	0.017	0.024	..
59	3/4	SK[b]	0.16	1.30	0.03	0.011	0.029	..
60	1	SK	0.18	0.48	0.06	0.012	0.029	..
61	1	SK	0.32	0.44	0.05	0.009	0.030	..
62	1	SK	0.23	0.54	0.12	0.012	0.041	..
63	1	SK	0.22	1.31	0.01	0.019	0.038	..
64	1	ABS-B	0.14	0.71	0.05	0.014	0.032	..
65	1 1/4	A201	0.15	0.58	0.20	0.009	0.029	..
66	1 1/4	A201	0.21	0.37	0.26	0.012	0.027	..
67	3/4	A201	0.15	0.55	0.19	0.021	0.034	..
68	2	HTS	0.26	0.40	0.01	0.022	0.026	..
69	6	A201	0.17	0.62	0.19	0.012	0.036	..
70	7 5/8	A293	0.28	0.64	0.15	0.010	0.013	2.56 Ni, 0.52 Mo, 0.06 V
71	1	SK	0.19	0.47	0.08	0.004	0.025	..
72	1	HTS	0.12	0.96	0.27	0.013	0.023	0.10 V
73	1	HTS	0.13	1.08	0.27	0.014	0.028	0.09 V
74	1 1/4	HTS	0.12	1.10	0.28	0.014	0.024	0.06 V
75	1 1/8	HTS	0.14	0.95	0.21	0.013	0.024	0.05 V
76	1	HTS	0.18	1.13	0.22	0.018	0.032	0.06 V
77	1 3/4	SK[b]	0.14	0.97	0.02	0.005	0.022	..
78	1 3/4	SK[b]	0.16	1.26	0.05	0.010	0.018	..
79	4 1/2	A212	0.27	0.79	0.23	0.012	0.023	..
80	1 1/4	ABS-C	0.14	0.71	0.22	0.010	[a]	..
81	1 1/4	ABS-C	0.16	0.68	0.22	0.011	[a]	..
82	1 1/4	ABS-C	0.15	0.74	0.27	0.012	[a]	..
83	1 1/4	ABS-C	0.16	0.85	0.31	0.026	[a]	..
84	1 1/4	ABS-C	0.16	0.82	0.29	0.025	[a]	..
85	1 1/4	ABS-C	0.16	0.79	0.32	0.013	[a]	..
86	1 1/4	ABS-C	0.15	0.71	0.27	0.015	[a]	..
87	1 1/4	ABS-C	0.15	0.74	0.24	0.024	[a]	..
88	7/8	HTS	0.16	1.02	0.29	0.020	0.034	0.10 V
89	1	HTS	0.13	1.07	0.28	0.013	0.026	0.10 V
90	6	A302	0.24	1.35	0.27	0.016	0.032	0.49 Mo

veloped in the standard test can be measured in various ways. Lateral contraction across the width of the specimen was used originally, and surface elongations measured by means of photogrid techniques have also been used by NRL as a measure of the relative index of strain. Such measurements, however, are time consuming and are not readily adaptable to establishing satisfactory test conditions for a large number of different specimens. The most rapid, and simplest, procedure for evaluating the approximate level of surface strain is that which considers the brittle crack-starter weld as a "built-in" strain gage. The weld-crack opening is then considered to be indicative of the plastic surface strain developed in the drop-weight specimen. The use of such a parameter for the relative index of strain, however, must be restricted to measurements made in "hot tests" (at temperatures approximately 100° F or more above the NDT temperature). At temperatures near NDT, the weld-crack opening is generally increased by partial cracking of the plate (Fig. 4).

To establish the strain index developed in reference-standard specimens in terms of weld-crack opening, several specimens of each of 15 steels were used. These were tested with different impact energies in order to measure the limiting size of the weld-crack opening for specimens which are deflected just enough to contact the anvil stop. Low-magnification visual measurements of weld cracks are reported as the average of three readings made at the position of largest opening. Figure 5 depicts the results of weld-crack-opening determinations for reference-standard test specimens cut from 15 different steels. The numbers to the left of each symbol represent the height in feet from which a 100-lb weight was dropped to impact the various specimens. The vertical lines connecting specimens tested with the same impact energies indicate that a constant level of surface strain is not always obtained, even for specimens cut from the same steel. It is noted, however, that all standard specimens which developed crack openings less than 12 mils failed to contact the 0.3-in. anvil stop, and all those which developed crack openings greater than 18 mils did contact the stop. Within the range of 12 to 18 mils, the standard specimens may or may not contact the 0.3-in. anvil stop. Therefore, a range of 12 to 18 mils weld-crack opening can be chosen to describe the relative index of strain developed in the reference-standard test for all of these steels, which vary from semikilled carbon steels to the quenched and tempered HY80 alloy steels. This range of weld-crack opening is considered the normalization limits of strain developed in reference-standard test specimens. For NDT determinations with different size specimens, the test span and anvil stop used must give strain values as measured by the weld-crack opening which are comparable to those shown in Fig. 5.

Specimens of $3\frac{1}{2} \times 14$ in. size which varied in thickness from $\frac{1}{2}$ to $1\frac{1}{2}$ in. were similarly drop-weight tested using the same 12-in. span and 0.3-in. anvil stop. Figure 6 depicts the results of the relative index of strain (weld-crack opening) measurements obtained for these steels. It is apparent that the $\frac{1}{2}$-in. thick specimens (Fig. 6, top left) develop strain values significantly lower than those obtained with reference-standard specimens. In accordance with the previously described NDT concepts, these $\frac{1}{2}$-in. thick specimens should require an adjustment of span or anvil stop in order to develop strain values within the normalization limits of the reference-standard test. Because of the significantly higher strain values developed in the $1\frac{1}{2}$-in. thick specimens (Fig. 6, bottom right), similar adjustments of span or anvil stop are required for drop-weight tests of $1\frac{1}{2}$- $\times 3\frac{1}{2}$- $\times$ 14-in. specimens. Tests with the $\frac{3}{4}$-in. thick specimens (Fig. 6, top right), on the average, result in the development of only slightly lower strains, although a few of these steels fall below the normalization limits. The $1\frac{1}{4}$-in. thick specimens (Fig. 6, bottom center) develop strains that are, on the average, only slightly

higher than those obtained with 1-in. thick reference-standard drop-weight specimens. Tests of $^{7}/_{8}$- × $3^{1}/_{2}$- × 14-in. (and probably $1^{1}/_{8}$- × $3^{1}/_{2}$- × 14-in.) specimens on the 0.3-in. anvil stop (Fig. 6, bottom left), on the other hand, seem to be fully compatible with the reference-standard tests.

The use of a constant 0.3-in. stop for different thickness specimens cut from the same steel is expected to result in fictitious or apparent NDT temperatures* which deviate from the reference-standard NDT in accordance with the deviations observed in the relative index of strain measurements. Figure 7 and Table 3 illustrate this fact for $^{3}/_{4}$- and $1^{1}/_{4}$-in. thick specimens which were shown in tests on a 0.3-in. anvil stop (Fig. 6) to develop, respectively, slightly lower and slightly higher strain values than the reference-standard specimens. The data of Fig. 7 are plotted in terms of the *apparent* NDT displacement from the reference-standard NDT. Thus, for any particular steel, the temperature at the reference-standard NDT line is considered to be the reference-standard test NDT determined for that steel; for example, when $1^{1}/_{4}$-in. thick specimens of steels No. 2 and 38 were tested on the 0.3-in. anvil stop, apparent NDT's of 50 and 20° F, respectively, were obtained. These are plotted at 10° F above the reference-standard NDT line to indicate that they occurred at temperatures which were 10° F higher than the reference-standard NDT temperatures of 40 and 10° F, respectively, given in Table 3. Figure 7 indicates that the apparent NDT is only slightly higher than the reference-standard NDT for the $1^{1}/_{4}$-in. thick specimens and slightly lower for the $^{3}/_{4}$-in. thick specimens of the same steel tested on a constant 0.3-in. anvil stop. With only one exception ($^{3}/_{4}$-in. thick specimens from steel No. 6), the displacement from the reference-standard NDT is shown to be exceedingly small. Accordingly, steels which vary in thickness from $^{3}/_{4}$ to $1^{1}/_{4}$ in. have been tested at NRL with the same specimen size, span and stop as used for reference-standard tests. The NDT results obtained are considered to be within the engineering accuracies of the reference-standard test.

Because the strain values of $^{1}/_{2}$-in. thick steels are significantly below the normalization limits of the reference-standard test (Fig. 8, top left), a 0.3-in. anvil stop should not be used for this specimen size. As expected, the apparent NDT of $^{1}/_{2}$- × $3^{1}/_{2}$- × 14-in. specimens is significantly below the reference-standard NDT (Fig. 8, bottom left). Although the use of greater deflections (0.5-in. stop) results in comparable index of strain values (Fig. 8, top center), the flexibility of a long thin beam precludes a consistent duplication of the reference-standard NDT (Fig. 8, bottom center). A test span shorter than 12 in. should be used for all specimens

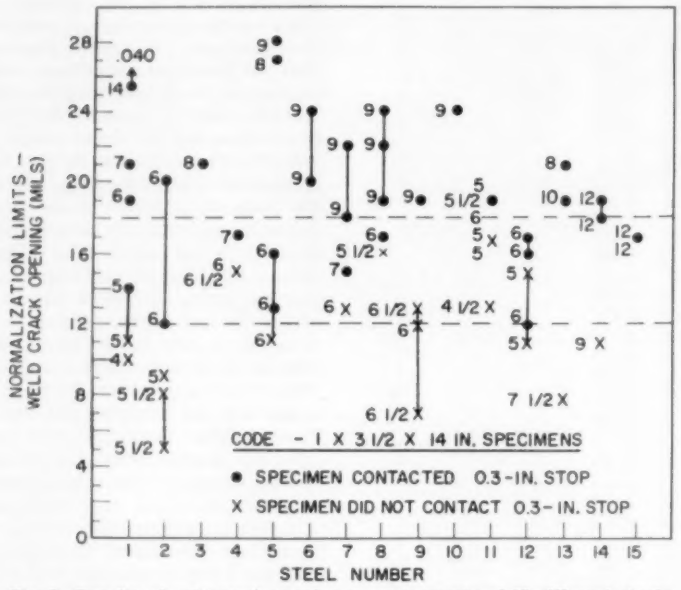
NORMALIZATION LIMITS – WELD CRACK OPENING (MILS)
CODE – 1 X 3 1/2 X 14 IN. SPECIMENS
● SPECIMEN CONTACTED 0.3-IN. STOP
X SPECIMEN DID NOT CONTACT 0.3-IN. STOP
STEEL NUMBER

Fig. 5—Results of weld-crack-opening measurements of 15 different steels tested at approximately 100° F above their respective NDT temperatures. Note the 12- to 18-mil crack-opening range within which incipient contact is made with the 0.3-in. anvil stop

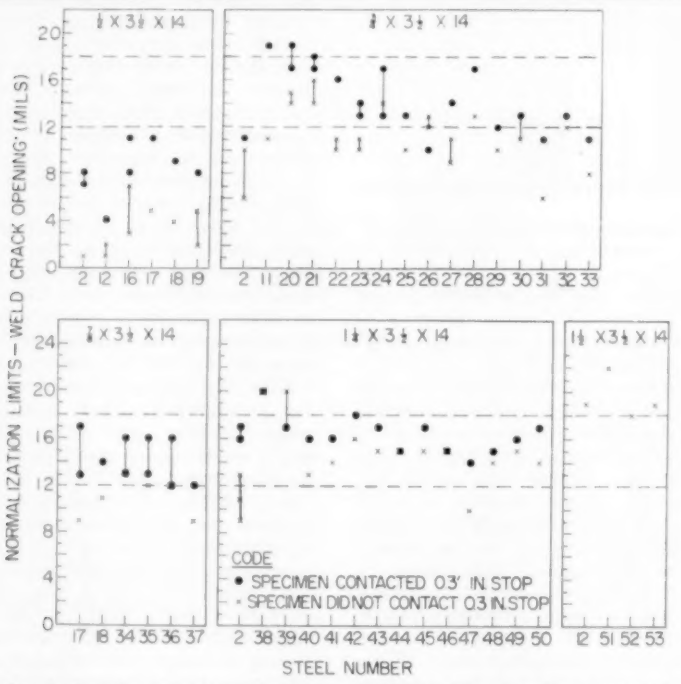
NORMALIZATION LIMITS – WELD CRACK OPENING (MILS)
CODE
● SPECIMEN CONTACTED 0.3' IN. STOP
SPECIMEN DID NOT CONTACT 0.3 IN. STOP
STEEL NUMBER

Fig. 6—Results of weld-crack-opening measurements of various steels of varying thicknesses all tested on the 0.3-in. anvil stop. Results show $^{1}/_{2}$- and $1^{1}/_{2}$-in. thick steels to be, respectively, understrained and overstrained on this anvil in comparison with the standard specimen (see Fig. 5)

* The highest temperature at which one or more specimens break in the drop-weight test.

Table 3—Comparison of NDT of $^3/_4$- and $1^1/_4$-in. Thick Specimens with Reference-standard NDT[a]

Steel No.	Original thickness, in.	Steel type	Nil-ductility transition temperature, °F: Reference-standard 1 × $3^1/_2$ × 14	$^3/_4$ × $3^1/_2$ × 14	$1^1/_4$ × $3^1/_2$ × 14
2	$1^1/_4$	SK	40	20	50
6	1	HTS	−30	−60	−40
11	2	A201	−20	−30	..
12	3	A201	−30	−40	..
38	$1^1/_4$	SK[b]	10	0	20
39	$1^1/_4$	SK[b]	0	−10	10
53	$1^1/_2$	HTS	−10	−30	..
54	$1^1/_4$	SK[b]	10	−10	20
55	$1^1/_2$	SK[b]	10	−10	..
56	$1^1/_2$	SK[b]	10	0	..
57	$1^1/_2$	SK[b]	20	0	..
60	1	SK	20	0	..
64	1	ABS-B	10	−10	..
65	$1^1/_4$	A201	50	..	60
66	$1^1/_4$	A201	80	..	90
69	6	A201	−10	−30	..
70	$7^5/_8$	A293	130	110	..
71	1	SK	20	10	..
72	1	HTS	0	−10	..
73	1	HTS	−20	−30	..
74	$1^1/_4$	HTS	−50	−60	−30
75	$1^1/_8$	HTS	−20	−40	..
76	1	HTS	−30	−30	..
77	$1^3/_4$	SK[b]	10	−10	..
78	$1^3/_4$	SK[b]	0	−10	..
80	$1^1/_4$	ABS-C	10	..	10
81	$1^1/_4$	ABS-C	20	..	30
82	$1^1/_4$	ABS-C	−20	..	0
83	$1^1/_4$	ABS-C	0	..	10
84	$1^1/_4$	ABS-C	−10	..	0
85	$1^1/_4$	ABS-C	−10	..	−20
86	$1^1/_4$	ABS-C	0	..	−10
87	$1^1/_4$	ABS-C	0	..	10

[a] All tests conducted on 12-in. span and 0.3-in. anvil stop.
[b] Semikilled, low-carbon, high-manganese experimental heats.

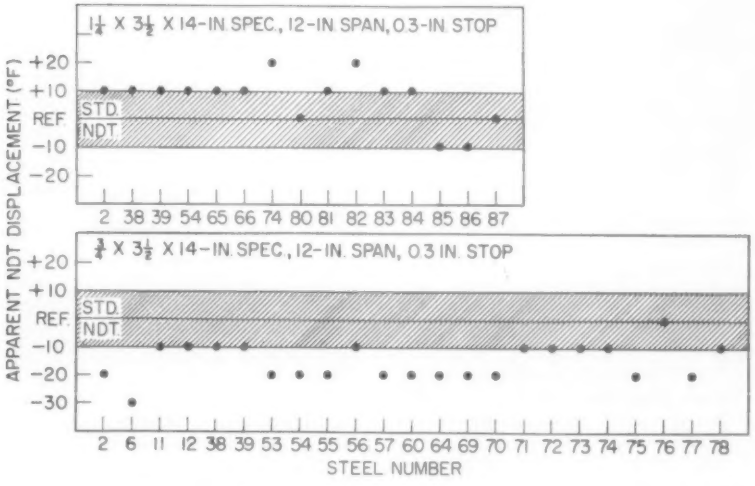

Fig. 7—NDT determinations of $^3/_4$- and $1^1/_4$-in. thick specimens of several steels tested on the standard 0.3-in. anvil stop are slightly displaced from the reference-standard NDT determined on 1-in. thick specimens as a result of, respectively, slightly lower and higher strain conditions

which are less than $^3/_4$ in. thick in order to avoid problems involving flexibility of long thin beams. For $^1/_2$-in. thick steels, a 4-in. span and an 0.090-in. anvil stop give strain values within normalization limits (Fig. 8, top right). As a matter of fact, the apparent NDT determinations with these $^1/_2$-in. thick subsize specimens are in much better agreement with NDT results obtained for any given steel in reference-standard tests (Table 4 and Fig. 8, bottom right).

The relative index of strain developed in tests of $1^1/_2$-in. thick specimens on a 0.3-in. stop is significantly higher than that developed in the reference-standard test specimen (Fig. 6). Limited drop-weight tests conducted with a few steels

Table 4—Comparison of NDT of $^1/_2$-in. Thick Subsize Specimens with Reference-standard NDT

Steel No.	Original thickness, in.	Steel type	Nil-ductility transition temperature, °F: Reference-standard 1 × $3^1/_2$ × 14	$^1/_2$ × 2 × 5 (0.090-in. stop) (4-in. span)
2	$1^1/_4$	SK	40	20
5	1	HTS	10	−10
8	1	HTS	−30	−40
9	1	HTS	−20	−40
11	2	A201	−20	−30
12	3	A201	−30	−30
36	$^7/_8$	HTS	0[a]	10
53	$1^1/_2$	HTS	−10	−10
88	$^7/_8$	HTS	−30[a]	−30

[a] Specimens were $^7/_8$ in. thick.

Table 5—Comparison of NDT of $1^1/_2$-in. Thick Specimens with Reference-standard NDT

Steel No.	Original thickness, in.	Steel type	Nil-ductility transition temperature, °F: Reference-standard 1 × $3^1/_2$ × 14	$1^1/_2$ × $3^1/_2$ × 14 (0.2-in. stop 12-in. span)
11	2	A201	−20	−10
12	3	A201	−30	−30
53	$1^1/_2$	HTS	−10	−10
55	$1^1/_2$	SK[a]	10	20
56	$1^1/_2$	SK[a]	10	30
57	$1^1/_2$	SK[a]	20	30
68	2	HTS	30	30
70	$7^5/_8$	A293	130	140
79	$4^1/_2$	A212	−10	0

[a] Semikilled, low-carbon, high-manganese experimental heat.

indicated that the apparent NDT of a given steel was raised by at least 30° F when $1^1/_2$- × $3^1/_2$- × 14- in. specimens were tested on a 0.3-in. stop. However, when a normalization of conditions is effected by testing these specimens on a 0.2-in. stop, the apparent NDT results essentially duplicate those of the reference-standard specimen as shown in Fig. 9 and Table 5.

In order to facilitate contemplated studies involving radiation damage to structural materials, extensive investigations were conducted with subsize specimens to establish optimum conditions which would consistently duplicate results of the reference-standard test. Neither full-thickness specimens of the heavy-section steels involved nor even reference-standard specimens cut from these steels could be considered for this program because of limited reactor space and consequent handling problems. Cut-down specimens varying in thickness from $^1/_2$ to 1 in. and in width from $3^1/_2$ to 2 in. were studied instead. These were tested empirically to determine their relative index of strain (weld-crack opening) on a variety of anvil stops and spans. The final selection of a $^5/_8$- × 2- × 5-in. specimen was dictated in part by the fact that it represented the largest specimen which could be bundled conveniently for charging into the available reactor-port spaces. Normalization limit studies indicated that surface strains equivalent to those of the reference-standard test were obtained when these subsize specimens were tested on a 4-in. span with an 0.075-in. anvil stop (Fig. 10, top). Subsequent apparent NDT determinations with such specimens displayed excellent agreement with the reference-standard NDT results obtained for 26 steels as shown in Fig. 10, bottom, and Table 6.

Table 6—Comparison of NDT of $^5/_8$-in. Thick Subsize Specimens with Reference-standard NDT

Steel No.	Original thickness, in.	Steel type	Nil-ductility transition temperature, °F: Reference-standard 1 × $3^1/_2$ × 14	Nil-ductility transition temperature, °F: $^5/_8$ × 2 × 5 (0.075-in. stop 4-in. span)
1	1	SK	20	20
5	1	HTS	10	0
6	1	HTS	−30	−40
7	1	HTS	−30	−40
8	1	HTS	−30	−30
9	1	HTS	−20	−30
10	1	HTS	−30	−40
11	2	A201	−20	−20
12	3	A201	−30	−40
14	1	HY80	−130	−120
38	$1^1/_4$	SK[a]	10	0
39	$1^1/_4$	SK[a]	0	0
54	$1^1/_4$	SK[a]	10	0
55	$1^1/_2$	SK[a]	10	10
56	$1^1/_2$	SK[a]	10	10
57	$1^1/_2$	SK[a]	20	10
60	1	SK	20	30
61	1	SK	40	40
62	1	SK	20	30
63	1	SK	0	0
64	1	ABS-B	10	10
65	$1^1/_4$	A201	50	50
66	$1^1/_4$	A201	80	80
68	2	HTS	30	40
69	6	A201	−10	−20
70	$7^3/_8$	A293	130	120

[a] Semikilled, low-carbon, high-manganese experimental heats.

Normalization Procedures for Heavy-section Steels

Full-thickness drop-weight tests of heavy-section steels were first started with a 6-in. thick boiler

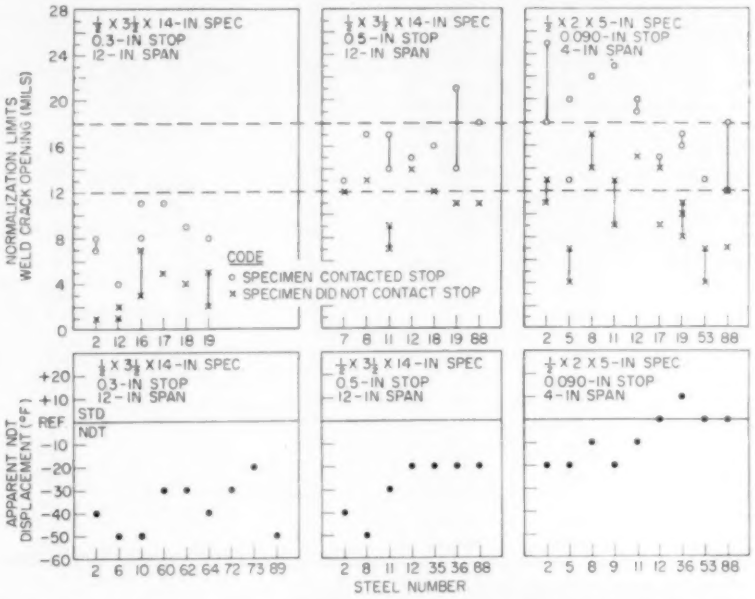

Fig. 8—Weld-crack-opening measurements (top) and NDT determinations (bottom) for $^1/_2$-in. thick specimens of various steels: (left) strain conditions (crack-opening) lower than standard account in part for the downward displacement of apparent NDT; (center) flexibility of 14-in. long specimen accounts for low NDT under normalized strain conditions; (right) increased rigidity of 5-in. long specimen results in NDT values comparable to those of the reference-standard specimens

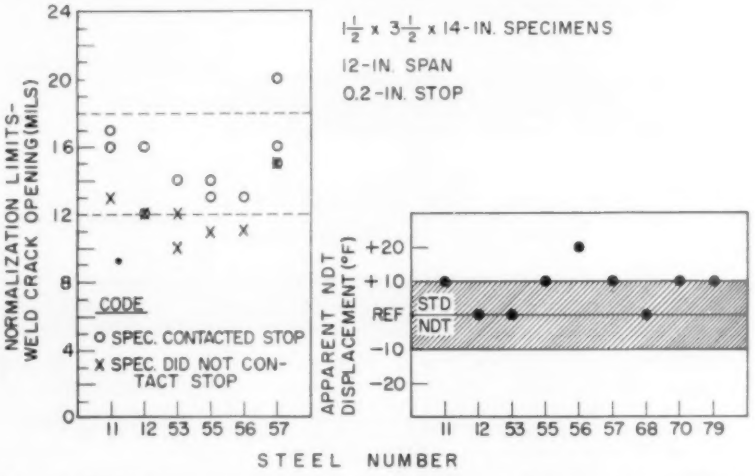

Fig. 9—Weld-crack-opening measurements (left) and NDT determinations (right) for $1^1/_2$-in. thick specimens of various steels showing that strain conditions and NDT results approximating those of the reference-standard tests are obtained on a 0.2-in. anvil stop for this specimen size

plate steel (No. 69) available from NRL stock. Because of the limited quantity of this and all other thick steels which have since been tested, it has not been possible to establish conditions of span and stop necessary for normalization procedures. Instead, visual normalization procedures were employed for full-thickness tests. These involved open-anvil tests and the adjustment of weight and drop conditions so that the impact was only slightly higher than the minimum required to develop incipient surface yielding of the specimen and, therefore, produce a visible crack in the weld. Such procedures were employed in the original drop-weight studies, and subsequently have been used for full-thickness NDT determinations of all heavy-section steels so far evaluated at NRL.

It was immediately obvious that the rigidity of a 6-in. thick beam precluded drop-weight tests of specimens on a 12-in. span. The heavy-section steel program was planned to permit NDT comparisons between full-thickness and reference-standard specimens cut from the same steel surface. Accordingly, the specimen size used for the various thicknesses was fixed arbitrarily at lengths which would subsequently permit convenient saw cutting of reference-standard specimens. Excellent agreement between full-thickness NDT, using visual normalization procedures, and reference-standard NDT is obtained as shown in Table 7. Excellent agreement is also shown in Table 7 for additional NDT determinations made for several of these thick steels using normalization procedures described previously for specimen sizes which varied from $^1/_2$ to $1^1/_2$ in. in thickness.

The relative size and shape of some of the drop-weight specimens which have been tested to date are shown in Fig. 11. Of particular significance are the indicated NDT determinations for six specimen sizes which were cut from steel No. 70. This steel was taken from the $7^5/_8$-in. A293 Ni-Mo-V pressure-vessel failure described in the literature[8] as correlation case No. 8. The brittle failure which started from a fatigue crack occurred at room temperature (70° F) and resulted in a complete circumferential fracture; the crack was also propagated up throughout almost the entire length of the outer shell. The NDT temperature for both the reference-standard and full-thickness specimens was 130° F, thus indicating correlation with service. Drop-weight tests of this steel in four other specimen sizes using normalization procedures showed excellent agreement with the reference-standard NDT (Fig. 11).

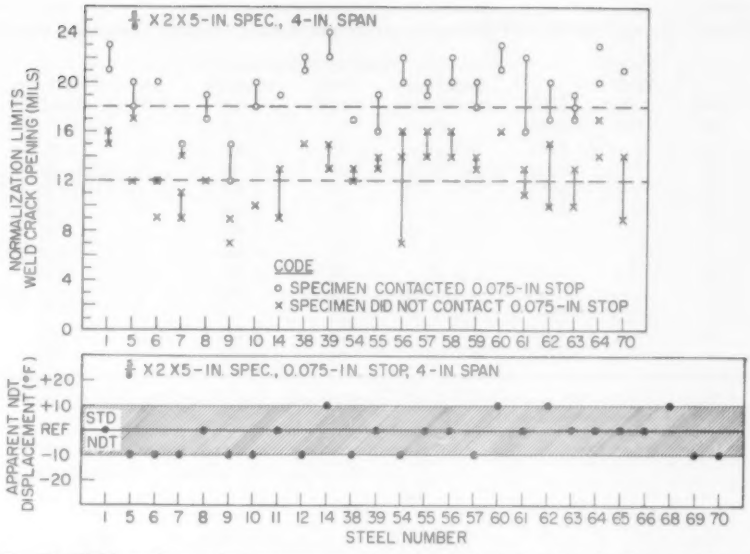
⅝ X 2 X 5-IN. SPEC., 4-IN. SPAN
NORMALIZATION LIMITS WELD CRACK OPENING (MILS)
CODE
o SPECIMEN CONTACTED 0.075-IN. STOP
× SPECIMEN DID NOT CONTACT 0.075-IN. STOP
⅝ X 2 X 5-IN. SPEC., 0.075-IN. STOP, 4-IN. SPAN
APPARENT NDT DISPLACEMENT (°F)
STD
REF
NDT
STEEL NUMBER

Fig. 10—Weld-crack-opening measurements (top) and NDT determinations (bottom) for $^5/_8$-in. thick subsize specimens of various steels showing that strain conditions and NDT results approximating those of the reference-standard tests are obtained on a 0.075-in. anvil stop for this specimen size

Fig. 11—Range of specimen sizes tested in the NRL drop-weight test, all of which employed the same brittle crack-starter weld. Normalization procedures permitted excellent agreement in NDT among the different size specimens of the same service-failure steel, as indicated by the temperatures. Dimensions shown are specimen thicknesses. Third specimen from top has central section machined to eliminate oxygen-cut edge effects

Summary Discussion and Conclusions

The NDT concept is based on the ability of a given steel to exhibit a small amount of plastic deformation in the presence of a cleavage crack. In order to permit testing of a wide variety of steel types, test conditions (12-in. span, 0.3-in. stop) for specimens of specific dimensions (1 × $3^1/_2$ × 14 in.) were established. Empirical correlations with service-

Table 7—Comparison of NDT of Heavy-section and Reduced-section Specimens with Reference-standard NDT

Steel No.	Original thickness, in.	Steel type	Heavy-section tests: Specimen dimensions, in.	Test span, in.	Impact energy, ft-lb	VN[a] NDT, °F	Reference-standard NDT, °F	Reduced-section tests[b]: 3/4-in. NDT, °F	1 1/2-in. NDT, °F	5/8-in. NDT, °F	1/2-in. NDT, °F
11	2	A201	3 1/2 × 28	26	2,000	−20	−20	−30	−10	−20	−30
12	3	A201	3 1/2 × 28	26	3,700	−30	−30	−40	−30	−40	−30
51	4 1/2	A212	4 1/2 × 72	70	5,500	0	−20	...	...	...	...
52	4 1/2	A212	4 1/2 × 72	70	5,500	0	−20	...	...	...	...
68	2	HTS	3 1/2 × 30	28	1,600	30	30	...	30	40	...
69	6	A201	6 × 30	28	16,000	0	−10	−30	...	−20	...
70	7 5/8	A293	6 × 60	58	24,000	130	130	110	140	120	110
77	1 3/4	SK[c]	3 1/2 × 30	28	600	0	10	−10	...	...	...
78	1 3/4	SK[c]	3 1/2 × 30	28	600	0	0	−10	...	...	...
79	4 1/2	A212	4 1/2 × 72	70	5,500	0	−10	...	0	...	...
90	6	A302	6 × 60	58	15,000	40	50	...	...	...	...

[a] Visual procedures were used to determine when surface strain was normalized in the test.

[b] Reduced-section specimen data:

Dimensions	*Span*	*Stop*
3/4 × 3 1/2 × 14	12	0.3
1 1/2 × 3 1/2 × 14	12	0.2
5/8 × 2 × 5	4	0.075
1/2 × 2 × 5	4	0.090

[c] Semikilled, low-carbon, high-manganese experimental heats.

failure steels indicate that these test conditions are valid for the prediction of service performance. The consistent ability to produce laboratory fractures of nil-ductility (no prefracture ductility) at temperatures of service failures has permitted the formulation of new concepts by which service-fracture performance can be predicted from laboratory test data.

Because of the latitude permitted in nominal test procedures, it is considered preferable to conduct drop-weight tests with a central anvil stop. To be technically accurate, the anvil stop should be adjusted to permit different deflections for different steel types if an exactly constant level of strain is to be obtained with similar size specimens. However, the data for reference-standard specimens indicate that not only specimens from different steels but even several specimens cut from the same steel develop strain values which vary over a small range. Accordingly, the limits of the index of strain developed in the standard test represent a practical technical limit upon which a normalization of test variables can be based. In terms of the limits of strain developed in standard test specimens, normalization procedures have been presented herein to establish anvil stop and span conditions required for tests of specimens which vary from 1/2 to 1 1/2 in. in thickness. A simple method for establishing empirically whether different stop conditions are within satisfactory normalization limits of allowable strain has been described in terms of the weld-crack opening developed under minimum energy impacts required to make the specimen contact the stop. This procedure, or any other valid measurement of surface strains, can be utilized to establish new stop conditions for odd-size test specimens.

Other investigators who have studied the problem of effect of section size on notch toughness of materials have invariably employed geometrically proportioned specimens with relatively dull, machined notches. In addition to problems related to notch acuity, their results have sometimes been influenced by changes in the metallurgical condition of the material at the root of the machined notch. The drop-weight test, on the other hand, is readily amenable to section-size studies involving tests of the same steel surface, i.e., constant metallurgy, and with the same sharp, cleavage crack.

It has been demonstrated that the apparent NDT temperature of specimens of widely different sizes determined in tests conducted within normalization limits duplicates, within experimental and engineering requirements, the reference-standard NDT temperature of a given steel. Thus, the ability of a steel to yield, even slightly, in the presence of a cleavage crack and thereby preclude the initiation of brittle failure is determined by the metallurgy of a small volume of material at the root of the crack flaw. At temperatures above the NDT of a given steel such yielding is deemed possible. However, at or below the NDT, the steel is unable to tolerate even localized yielding at the root of a sharp crack without potentially being able to initiate brittle fractures.

Under properly normalized test conditions, the NDT determinations for a given steel tested in two or more specimen sizes are expected to be essentially identical (± 10° F). Test conditions which result in the development of surface strains considerably outside the normalization limits established for standard tests, on the other hand, result in apparent and fictitious NDT determinations which do not agree with the reference-standard NDT. The nil-ductility transition temperature of a given steel is determined only by reference-standard tests or properly normalized drop-weight tests. Drop-weight tests conducted under conditions which do not conform to the definition for NDT indicate fracture performance for the conditions of the test, and the results should not be called NDT.

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Spot Welding of Titanium Alloys

Heat-treated Ti – 6 AL – 4V, annealed and heat-treated Ti – 4AL – 3Mo – 1V, and annealed Ti – 5AL – 2.5Sn alloys found to be readily spot weldable

BY R. K. NOLEN, J. F. RUDY, H. SCHWARTZBART AND H. D. KESSLER

ABSTRACT. Procedures were developed for spot welding the following titanium alloys: annealed Ti – 5Al – 2.5Sn, annealed and heat-treated Ti – 4Al – 3Mo – 1V, and heat-treated Ti – 6Al – 4V. The program was an extension of a prior investigation on the spot welding of annealed Ti – 6Al – 4V.

It was found that, with the exception of current, the same parameters developed for the welding of annealed Ti – 6Al – 4V can be used to make satisfactory spot welds in the above alloys. The currents necessary to produce optimum spot welds in these alloys are somewhat higher than those for the annealed Ti – 6Al – 4V.

Spot strengths and ductility ratios of cross-tension strengths to tension-shear strengths for these alloys are similar to or slightly greater than those for annealed Ti – 6Al – 4V.

Introduction

This investigation is an extension of a program already reported* on the spot welding of annealed Ti – 6Al – 4V alloy.

This paper is concerned with the determination of welding parameters for spot welding the following

R. K. NOLEN, J. F. RUDY and H. SCHWARTZBART are associated with Armour Research Foundation, Chicago, Ill., and H. D. KESSLER is associated with Titanium Metals Corporation of America, Toronto, Ohio.

* Nolen, R. K., Rudy, J. F., Schwartzbart, H., and Kessler, H. D., "Spot Welding of Ti – 6Al – 4V Alloy," THE WELDING JOURNAL 37 (4), Research Suppl., 129-s to 137-s (1958).

Table 1—Chemical Analysis of Titanium Alloys

Alloy	Heat No.	Composition, wt % N	C	Fe	Mo	Al	V	Sn
Ti – 5Al – 2.5Sn (annealed)	M-5080	0.012	0.013	0.07	..	4.9	..	2.2
Ti – 4Al – 3Mo – 1V (annealed and heat treated)	M-5409	0.006	0.015	0.15	3.1	4.4	1.0	..
Ti – 6Al – 4V (heat treated)	M-4436	0.012	0.014	0.11	..	6.4	4.2	..
Ti – 6Al – 4V (heat treated)	M-4277	0.012	0.010	0.13	..	6.3	4.2	..
Ti – 6Al – 4V (annealed)	M-6095	0.011	0.014	0.10	..	6.2	4.2	..

Table 2—Mechanical Properties of Titanium-Alloy Sheet

Alloy	Heat No.		Yield strength (0.2 %) psi	Ultimate tensile strength, psi	Elongation, % in 2 in.	Minimum bend radius, t
Ti – 6Al – 4V (annealed)	M-6095	L	128,700	131,700	14.5	4.6
		T	128,600	131,800	13.5	4.6
Ti – 6Al – 4V (heat treated)	M-4436[a]	L	165,000	179,000	5.0	4.1
		T	156,000	176,000	3.0	4.1
Ti – 6Al – 4V (heat treated)	M-4277[a]	L	159,000	177,000	7.0	4.3
		T	162,000	179,000	5.0	6.6
		L	150,000	170,000	4.0	Failed
		T	159,000	174,000	4.5	Failed
Ti – 4Al – 3Mo – 1V (annealed)	M-5409	L	116,900	128,400	13.0	3.7
		T	126,400	133,000	11.0	3.0
Ti – 4Al – 3Mo – 1V (heat treated)	M-5409[b]	L	174,000	192,000	5.5	5.2
		T	160,000	192,000	4.0	Failed
		L	169,000	196,000	5.0	5.7
		T	174,000	197,000	5.0	5.2
Ti – 5Al – 2.5Sn (annealed)	M-5080	L	115,400	129,300	14.0	3.5
		T	119,300	125,200	13.5	2.9

[a] Heat treated at 1725° F (3 min) W.Q. + 975° F (8 hr); final sheet contained less than 0.009% H_2.
[b] Heat treated at 1650–1675° F (3 min) W.Q. + 975° F (8 hr); final sheet contained less than 0.007% H_2.

Table 3—Optimum Parameters for Spot Welding Titanium Alloys[a]

Alloy	Current range investigated: Beginning weld current, amp	Metal expulsion current, amp	Optimum current, amp	Cross-tension strengths at optimum current, lb/weld	Tension-shear strengths at optimum current, lb/weld	Ratio cross-tension strength over tension-shear strength
Ti – 4Al – 3Mo – 1V (annealed)	3580	27,300	16,000	1250	5750	0.21
Ti – 4Al – 3Mo – 1V (heat treated)	4300	20,700	14,000	1070	4900	0.22
Ti – 6Al – 4V (heat treated)	1630	15,400	12,000	1225	5950	0.21
Ti – 5Al – 2.5Sn (annealed)	1630	15,700	10,000	1250	5750	0.21
Ti – 6Al – 4V[b] (annealed)	3200	19,600	10,600	1000	5000	0.20

[a] These welds were made using 1500-lb electrode force, 10 cycles weld time and $\frac{1}{8}$ in. diam.—3-in. spherical radius Class 2 copper-alloy electrodes.
[b] Data taken from prior investigation. See footnote (*) above.

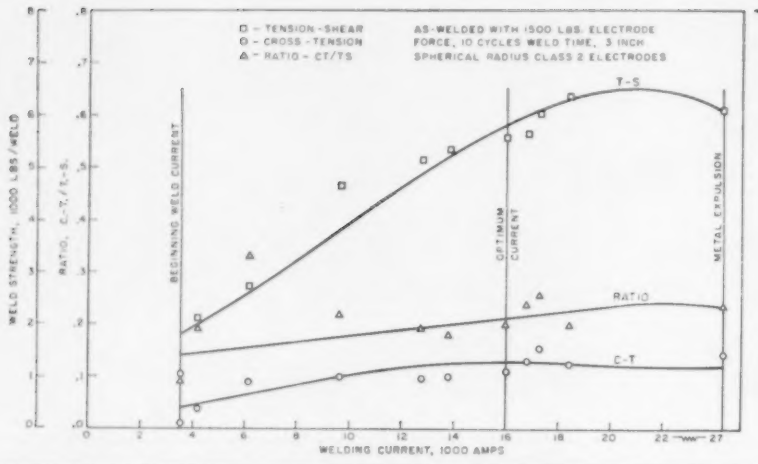

Fig. 1 (left)—Mechanical properties as functions of welding current for annealed Ti-4 Al-3Mo-1V alloy

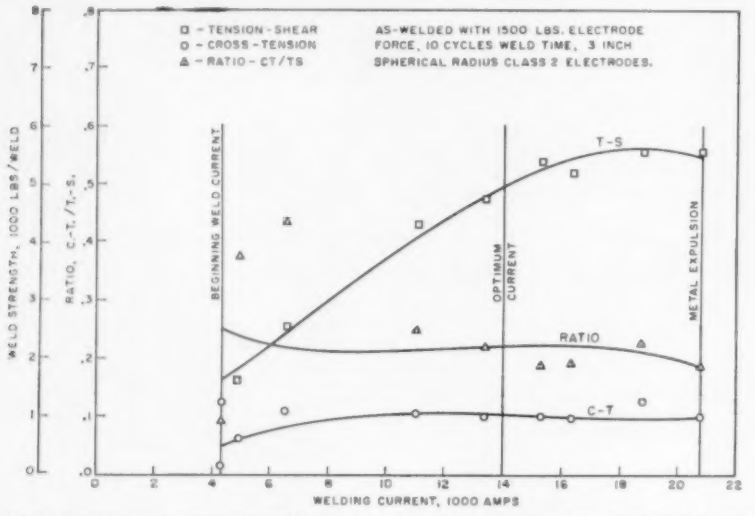

Fig. 2—Mechanical properties as functions of welding current for heat-treated Ti-4 Al-3Mo-1V alloy

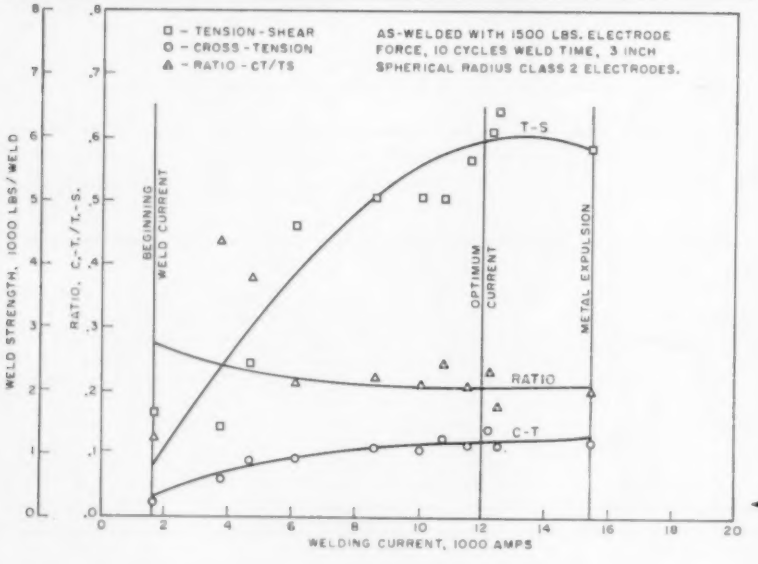

Fig. 3 (left)—Mechanical properties as functions of welding current for heat-treated Ti-6Al-4V alloy

titanium alloys:

Ti – 6Al – 4V (heat treated)
Ti – 4Al – 3Mo – 1V (annealed)
Ti – 4Al – 3Mo – 1V (heat treated)
Ti – 5Al – 2.5Sn (annealed)

Data from the previous work were used as a basis for the investigation of these alloys.

The experimental material was 0.062 in. thick. Table 1 shows chemical composition, and Table 2 shows mechanical properties of the various alloys used throughout the investigation.

Apparatus and equipment for this program were the same as in the previous work, with the exception of the current-measuring device.

In the present investigation, current was measured utilizing an oscilloscope equipped with a camera.

Spot-welding Parameters

The initial machine settings, electrode alloy and geometry, and specimen geometries used during this phase were based on the data demonstrated to produce optimum spot welds in 0.062-in. sheet as reported previously* for annealed Ti – 6Al – 4V.

The alloys were welded with 10 cycles weld time, 1500-lb electrode force, and 60 cycles for squeeze and hold times.

The welding current was varied from the point of minimum value for joining, up to the point of metal expulsion. Tension-shear and cross-tension test specimens were welded with these various current settings.

Figures 1 to 4 inclusive show the effect of increasing weld current on the spot strength for the various titanium alloys.

The optimum weld currents were chosen from these plots, taking also into consideration sheet separation, electrode indentation, weld-nugget diameter, and percent penetration. Satisfactory spot welds were produced by these optimum currents. However, the plots show that greater strengths can be obtained using higher than "optimum" currents (up to metal expulsion), provided the condition of sheet separation, etc., is not a major factor.

The values of optimum current, taken from the curves of Figs. 1 to 4, are tabulated in Table 3. In general, it can be said that the optimum currents for these alloys were

generally higher than the optimum current for spot welding annealed Ti – 6Al – 4V, which is also recorded in Table 3 for comparison. The difference in welding current requirement of the various alloys may be related to their different electrical conductivities. In general, it is observed that current requirement increases with increasing beta phase (Ti – 5Al – 2.5Sn up to Ti – 4Al – 3Mo – 1V). Since beta is the higher conductivity phase, the data show that the optimum welding current increases with increasing conductivity, as would be expected. The smaller current-requirement difference between heat-treated and annealed samples of the same alloy may possibly be due to a similar mechanism.

In regard to the mode of failure of the tension-shear and the cross-tension specimen, high-strength welds failed by button pull-out from one or both of the sheets, while the weaker welds failed at the faying surfaces.

Visual and metallographic examination of the spots for the various alloys indicated that sheet separation, electrode indentation, weld penetration and nugget diameters also increased with increasing welding current. It was found that the values of these variables were similar to those reported previously* for the annealed Ti – 6Al – 4V alloy.

Conclusions

The following conclusions may be drawn from this program on the spot welding of heat-treated Ti – 6Al – 4V, annealed and heat-treated Ti – 4Al – 3Mo – 1V, and annealed Ti – 5Al – 2.5Sn:

1. The alloys are readily spot weldable.

2. Except for current, welding parameters determined previously for the welding of annealed Ti – 6Al – 4V produce satisfactory welds in the present alloys. In general, the optimum currents for these alloys are higher than for annealed Ti – 6Al – 4V. A current dependence on the amount of beta phase in the alloy is indicated.

3. Tension-shear strengths for these alloys are similar to or somewhat higher than those for annealed Ti – 6Al – 4V welded under the same conditions.

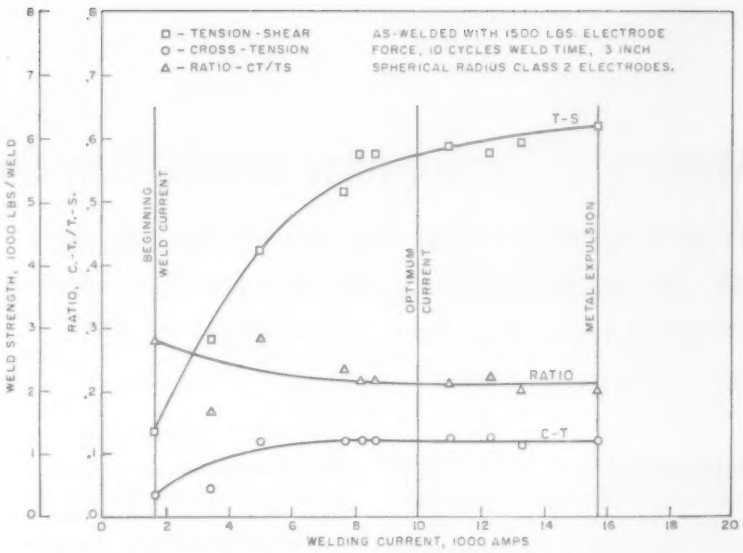

Fig. 4—Mechanical properties as functions of welding current for annealed Ti-5Al-2.5Sn alloy

Acknowledgment

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WRC BULLETIN NO. 48

Plastic Design of Pinned-Base Gable Frames

by Robert L. Ketter - 20 pages. Price $1.00.

After listing the basic assumptions of plastic analysis, this paper presents a method whereby complex multiple span, pinned-base, gable frames can be readily designed. Several design examples are carried out. The problem of economy in main member is also discussed and procedures are presented whereby the design of a "least weight" structure can be approached.
Copies may be purchased from the American Welding Society, 33 W. 39th St., New York 18, N. Y.

Welding of Medium-Alloy Chrome-Moly Steels

Problems encountered in welding crack-sensitive alloy steels are discussed and economical fabrication procedures intended to yield constantly sound, tough welds, are outlined by the author

BY KENNETH R. NOTVEST

Introduction

The history of welding the chrome-moly steels has established these materials as being extremely crack sensitive. Particularly so is the medium-alloy group from 3 to 10% alloy content which is air hardening. In an effort to reduce weld cracking, widely varying specifications and interpretations have crept into the picture. This may have been due to a lack of complete understanding of the mechanics of the system. These varying specifications make it difficult for a fabricator to standardize on one method known to produce good results. Some specifications often increase the cost of welding and occasionally fail to achieve the best physical properties in the completed weldment. This paper is intended to shed some light on the problems, along with a solution, believed to represent economical fabrication practice that will consistently yield sound, tough welds.

General Considerations

Base materials welded in this investigation consisted of wrought and cast 5% chromium–$^1/_2$% molybdenum steels generally conforming to AISI Type 502, and compatible weld metal deposited by inert-gas-shielded manual and submerged-arc processes.

The key to sound ductile welds lies in proper thermal treatment throughout the welding cycle, and reduction of carbon, hydrogen and oxygen from the melt. Conventional physical tests were made on as-welded specimens.[1] Tensile strength of 124,000 psi, yield at 108,000 psi and elongation of 25% were found. If these tests fully determined as-welded properties, it would be hard to explain how cracking could occur or how to prevent it.

It was deemed highly desirable to develop simple, easily performed tests that would reflect crack sensitivity with variations in procedure. In all cases, welding followed normal practice except the variable under test. Cooling rates were adjusted to averages found in production. Strictly isothermal treatment was not used.

Data for this paper were gained from both experimental and production welding.

Test Methods

In the belief that some welds will invariably contain some notch-type defects or stress raisers, it was considered necessary to determine the resistance to crack propagation when the weld was in the highly stressed martensitic condition on cool-down from welding. This test consisted of a two-pass weld with a heat input of 45,000 joules/inch, over a ground square butt joint securely restrained by a heavy yoke of compatible steel. The entire assembly was given any thermal treatment provided. No attempt was made to eliminate crater cracks as they were not in the area over the notch. Starts were also made outside the fracture area without back stepping. Accordingly, evidence of starting porosity and crater cracks was obtained for each preheat tested. It is of considerable interest to note that both types of defects disappeared at the same degree of preheat that was capable of preventing crack propagation in the notched and restrained joint. Considerable yielding within a small volume of weld metal was necessary if the joint was to avoid a cataclysmic failure.

It was desirable to gain knowledge of notch ductility at elevated and ambient temperatures. The same type of joint and welding conditions were used as in the restrained joint, but without the restraining yoke. The weld was tested by bending over the notch, causing the latter to propagate. The peak load and deflection were recorded with the product of the two used as a measure of notch ductility. The base of the notch was the fusion line of the weld.

Test welds were also radiographed and checked for hardness. Tensile tests and microphotos did not yield pertinent data.

Preheating

Existing codes[2] specify a minimum preheat of 450° F for these materials. General practice is to start at 500° F and maintain this temperature by reheating if necessary as long as welding progresses. Welding is not stopped unless one-third of the wall thickness or at least two passes are completed.

Besides driving off adhered moisture from the weld area, the purpose of preheating is to slow down the cooling rate of the weld and heat-affected zone. This permits the formation of more favorable microstructures and reduces the thermal gradient across the weld. With the great reduction of thermal and residual stresses gained by proper preheating, this step is one of the most important features in quality welding of this class of steels.

Some regard should be given to interpass and finish temperatures as affected by wall thickness, heat input and method of welding. Too high a finish temperature such as might be encountered with multi-pass automatic welding, would promote secondary hardening in the as-welded condition. Figure 1 depicts the as-welded and stress-relieved hardness values for two series of welds made with increasing preheat. As is evident from the data, the hardness after stress relief is

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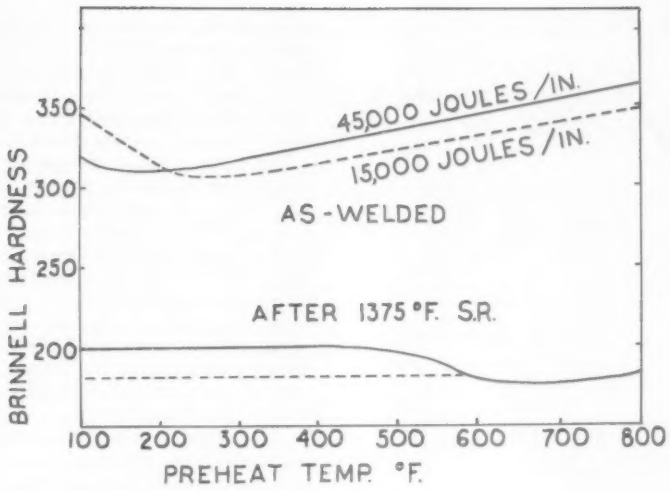

Fig. 1—As-welded and stress-relieved weld hardness as affected by preheat and heat input

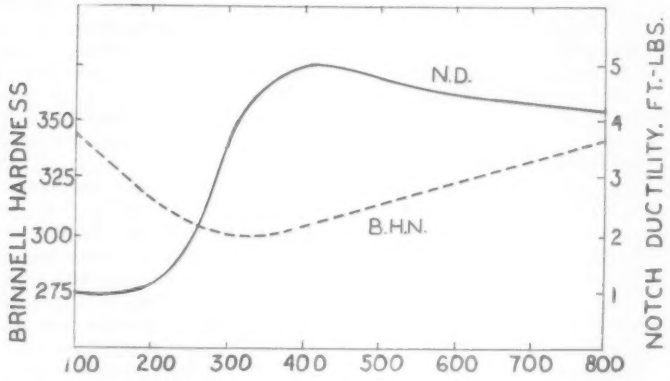

Fig. 2—The influence of preheat on as-welded hardness and notch ductility

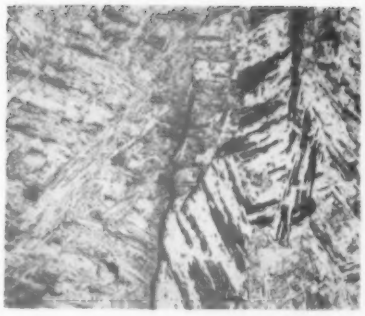

Fig. 3—Intergranular cleavage cracks in weld metal. ×400. (Reduced by 1/2 upon reproduction)

A. Intergranular cleavage fracture from 200 to 700° F tests

B. Transition fracture at 200° F

C. Transgranular cleavage fracture tested at 100° F

Fig. 4—Fracture characteristics in notch-ductility tests. × 5. (Reduced by 1/3 upon reproduction)

not greatly affected. Factors such as operator discomfort, lost time, poor control over the weld puddle and high as-welded hardness would rule out the high preheats such as 700 to 800° F. Other factors being equal, the amount of porosity and crater cracks encountered will be less with higher preheats, although other conditions have greater effect. Best physical properties and economics of welding would accrue by keeping preheat low when high finish temperatures are to be expected and vice-versa.

The role of preheat, as it affects the as-welded hardness and notch ductility, is shown in Fig. 2. The low notch ductility with 100 and 200° F preheat could be brought on by microcracks. In order to verify this, standard Reeves underbead cracking tests[3] were run at 0, 50, 100, 150 and 200° F. With 0.04% carbon weld deposit and 0.10% moisture in the electrode coating, no underbead cracks were observed, but the weld microcracking illustrated in Fig. 3 was found in the 50° F test. With 0.09% carbon deposit and 0.25% moisture in the coating, more extensive microcracking was observed from 0 to 100° F tests, and again no underbead cracks were found.

Using 45,000 joules/inch weave welds, best as-welded properties were obtained with 400 to 500° F preheats. With restrained joints, no failures of any kind were encountered in the as-welded condition or subsequent postheat or stress relief, when the initial preheat was 500° F minimum. A few tests were made using covered electrodes of higher carbon or moisture content. In each case, the preheat required to avoid failure rose an average of 100° F.

Properties of a Cooling Weld

As the temperature of the weld drops to the start of transformation to martensite below 800° F, the properties are typical of austenitic structures; that is, possessing moderate strength and hardness and considerable ductility. This condition changes until at 500° F down to the finish of the transformation at 200° F, the structure is sufficiently keyed up due to the martensite and internal stresses that the properties have little resemblance to any other temperature range. The most striking phenomena are the intergranular cleavage fractures along the prior austenite grain boundaries,[4] with low energy-absorption values for any temperature in this range. Every fracture, whether due to restraint, thermal stresses, hydrogen content or notch-slow-bend tests at 500 to 200° F, exhibited this same condition.

The transition to a transgranular cleavage fracture occurs below 200° F. Room-temperature fractures

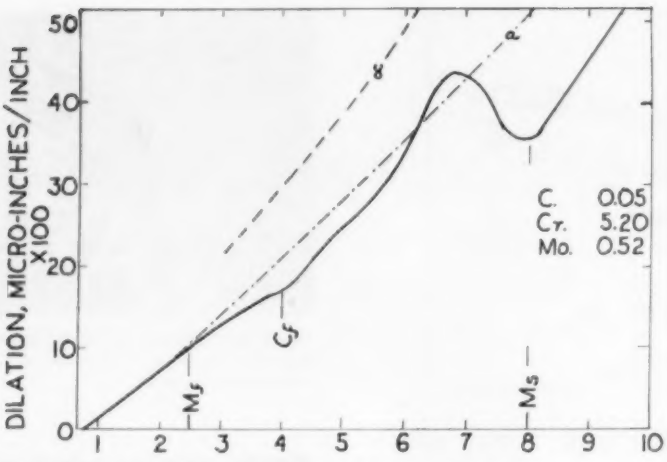

Fig. 5—Dilation of E502 weld metal air-cooled from 1700° F

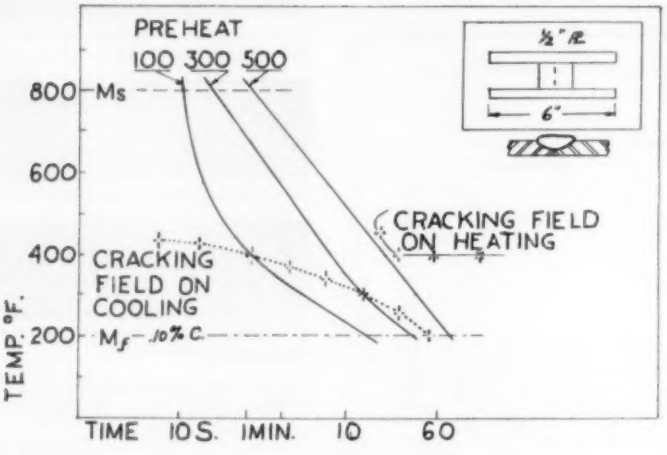

Fig. 6—Relation of time and temperature to failure in notched and restrained-joint weld tests

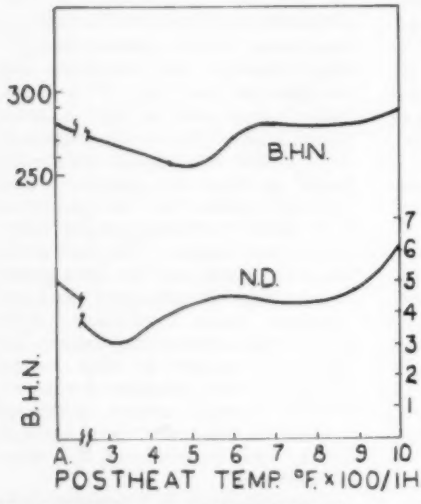

Fig. 7—Weld hardness and notch ductility as affected by postheat temperature

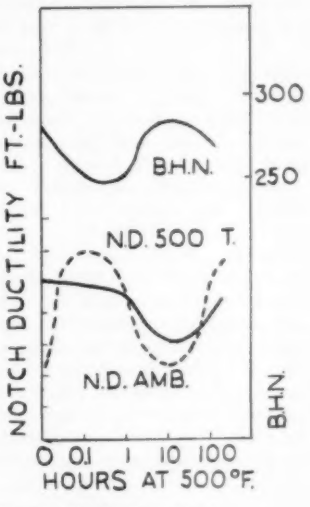

Fig. 8—Effect of postheat time on weld properties

were entirely transgranular. Figure 4 illustrates the fracture types obtained at characteristic temperatures. The notch ductility at ambient temperature was dependent upon weld cooling rate (as a function of preheat), as was the hardness.

The dilation as a function of temperature is shown in Fig. 5, along with data for austenite (gamma iron) and ferrite (alpha iron). The start of transformation to martensite below 800° F with the characteristic large expansion is obvious. Apparently with such a high Ms point, some self tempering is occurring which would explain the rather high rate of contraction following the bulk of the transformation at 650° F. Note that the point of maximum departure from the equivalent ferritic state, marked Cf, is the same temperature as the cracking field investigated with notched restrained joints. Below 200° F, the rate of contraction is the same as ferrite.

Figure 6 presents the results of notched and restrained joint weld tests. Without preheat, cataclysmic failure would occur shortly after welding, at 450° F. With increasing preheat, failure would be delayed and occur at a progressively lower temperature until, with a 500° F preheat, no failures were encountered. Cooling curves for typical preheated welds are shown.

Two variations from continuous cooling were investigated. In the first case, with an initial preheat of 300° F, which normally would not be sufficient to avoid fracture, cooling was delayed by placing in a furnace and holding for one hour and then cooling in air. This treatment approximated the cooling rate of a 500° F preheat weld and slow cooled by wrapping in an insulating blanket. Fracture was completely avoided. In the second case, with preheats from 250 to 400° F, the welds were immediately postheated starting from the preheat temperature at a rate of 500°F/hr. Cracking would always occur from 400 to 500° F. The failures were low-speed cracks, without the characteristic report of the high-speed cracks at lower temperatures. Irrespective of the thermal treatment, no failures occurred below 200° F.

Postheating

For the purpose of this paper, postheating is defined as any heat treatment, short of 1200° F, applied after conclusion of welding and before the weld has cooled substantially below the preheat temperature. Two general types of treatment are

considered. The first consists of locally heating the weld area for a short period of time to 750–1000° F, as a sort of stop gap before full furnace stress relief. An examination of a transformation diagram for 5% chrome–½% moly steels reveals that this treatment[5] carries the steel into the exact region where little if any transformation occurs; and since hydrogen will remain in the austenite, diffusion of hydrogen, desired to minimize cracking, is not possible. Relief from residual stresses is also very low. The worst feature of this treatment is secondary hardening.[6] That amount of martensite that transformed while the weld was below 800° F is tempered slightly with the precipitation of extremely fine carbides, resulting in a keyed structure with a considerable increase in hardness. The effect is noticeable between 500 and 1100° F, where true tempering begins to take place. Figure 7 depicts the hardness and notch ductility of a series of welds postheated at various temperatures. Holding in the range around 300° F appears to incubate notch brittleness and correlates with the cracking field already mentioned. Postheating from 500 to 900° F yields the same properties obtained with delayed cooling except for increased hardness. The effect of secondary hardening is also time sensitive, reaching a peak in 10 to 20 hr and dropping off after 100 hr at temperature. Figure 8 shows a typical curve of hardness and notch ductility as a result of postheating at 500° F for stated times. Values for notch ductility are given for both 500° F and ambient temperature tests. Since the purpose of this treatment was to safeguard the weld during the interval between welding and stress relief, and the net result was to increase the hardness, there is very little to recommend this treatment to justify the increased cost involved. The increased hardness as a result of postheating will usually result in an ultimate hardness after stress relief equal or perhaps slightly lower than an equivalent weld given a single stress-relief treatment. This is due to the initial carbide precipitation from postheating being in an advanced state for particle growth during stress relief, with the attendant softer structure. The second postweld heat treatment would be immediate stress relief without allowing the weld to cool below the preheat temperature, adding considerably to the cost of welding. Contrary to some opinions, the resultant weld properties are as good as any other variation of stress relieving. The hypothesis that a fairly large percentage of austenite, not transformed to martensite at low temperatures, will not transform at stress-relief temperatures, is not borne out by transformation diagrams or by physical tests of the welds so treated. Some small amount of hydrogen-retained austenite might escape transformation at the nose of the transformation curve.[7] This would result in increased stresses and hardness due to untempered martensite, but in high-quality low-hydrogen welds, the effect is not noticeable.

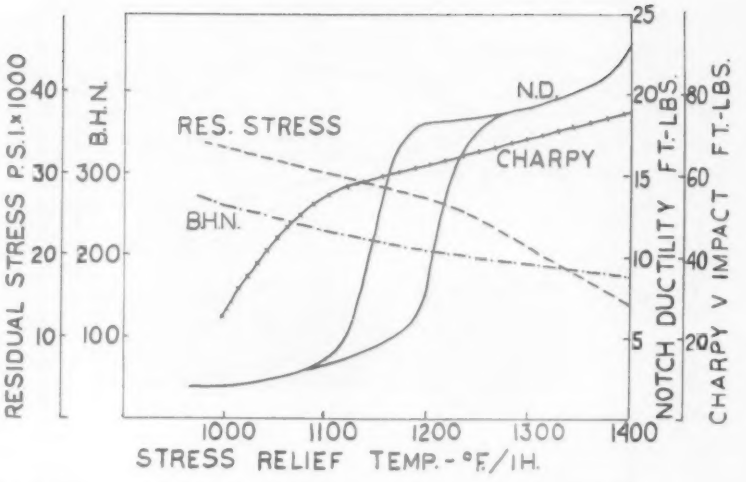

Fig. 9—Physical properties of welds as a function of stress-relief temperature

At the conclusion of welding, the average weld temperature is in the region of 550 to 850° F. Temperatures in the vicinity of 550°F are most conducive to transformation. Any hydrogen trapped in the martensite is some 400 times more capable of diffusion at this temperature than at ambient. Furthermore, any delayed cooling of the untransformed austenite would allow it to adjust any thermal stresses through equalization of temperature differences in the weld zone. This would reduce total stresses upon direct transformation. Accordingly, some means of providing slow cooling to ambient temperature is recommended. In practice it has been found adequate to wrap the weld in an insulating blanket at the conclusion of welding. Welds so treated possess the highest notch ductility short of stress relieving, and insure the as-welded structure to be free of excessive thermal stresses or local accumulation of hydrogen that might promote cracking.

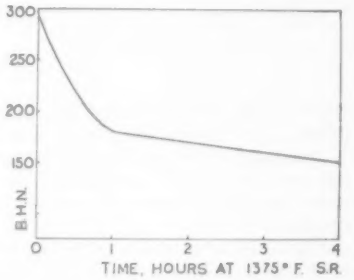

Fig. 10—Softening of welds with time at stress-relief temperature

This provides a moderately ductile structure that can safely be held for full furnace stress-relief treatment.

Stress Relieving

Thermal stress relief is defined for the purpose of this paper as that heat treatment above 1200° F and below the A_1 critical temperature for chrome-moly steels. It is intended to provide reduction of residual stresses and temper hard structures in the weld and heat-affected zones, resulting in improved physical properties. Figure 9 is a graph of weld properties as a function of stress-relief temperature. Minimum temperatures of 1300° F are required to obtain good fusion-line notch ductility with large order reduction of hardness and residual-stress values. Above 1400° F, the structure would start to revert to austenite which, upon cooling, could result in conditions similar to the as-welded condition with the benefits of the stress-relief treatment being lost. A phenomenon little appreciated is the pronounced effect of

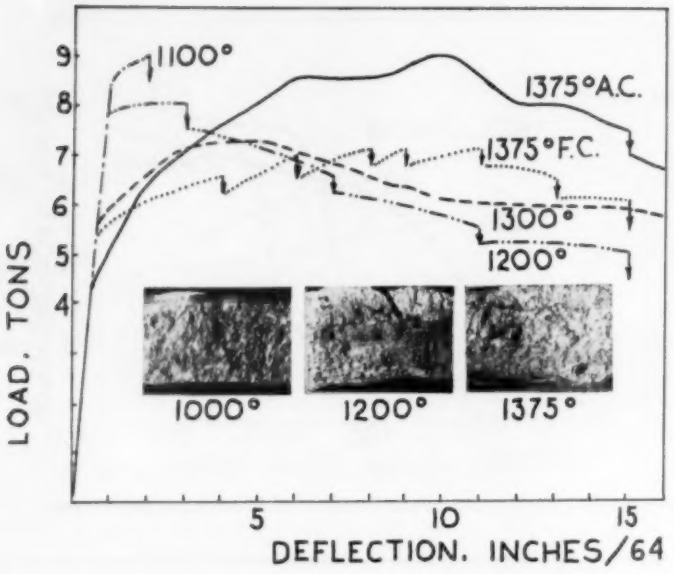

Fig. 11—Energy absorption and fracture characteristics of notch-ductility tests for various stress-relief treatments

stress relief upon cold-worked material. The metal will recrystallize to irregular-sized grains of ferrite and carbides, with a hardness the same as fully annealed material, average 140 Bhn.

Figure 10 depicts the softening of a weld as a function of time at 1375° F, the point of maximum effectiveness. As is evident, the greatest rate of softening occurs during the first hour and a relatively small increment in the next three hours. Unless thicknesses greater than one inch are being considered, the prolonged holding time could hardly be justified.

The fracture and energy-absorption characteristics of stress-relieved notch-ductility tests are summed up in Fig. 11. For a stress-relief temperature of 1200° F, judged to be the transition between low-energy-absorption cleavage fracture and high-energy-absorption shear fracture, the stress-strain curve consists of a series of steps representing small fractures followed by recovery. The 1000 and 1100° F tests were cataclysmic high-speed fractures. Test specimens stress relieved from 1300 to 1400° F would yield considerably in the notch area, absorbing appreciable energy before general tearing of the specimen started, coincident with a drop in the load. The fractograph consists of severely distorted metal. All the above tests were air cooled from stress relief.

An entirely different picture is exhibited by furnace cooling at 100° F/hr from stress relief. The medium-alloy chrome-moly steels are mildly susceptible to temper embrittlement. For a given welding technique, stress-relieved and air-cooled samples would average 190 Bhn. After a slow furnace cool, hardness would be 20 points higher with a low-carbon weld and 30 to 40 points higher for a 0.12% carbon weld. Charpy impact properties drop about 20%. The stress-strain curve of a notched specimen, slow furnace cooled, exhibits the partial fracture and recovery similar to the stress-relieved 1200° F test. The energy-absorption value is highly sensitive to the speed of testing, with an average reduction of 25% compared to air cooling. Specifications calling for slow cooling, such as 100° F/hr to 1000° F actually impair the physical properties of the weldment. The best properties consistent with uniform cooling to avoid introducing thermal stresses and possible warping, is to air cool, or at least to use a moderately rapid cooling rate to below 800° F.

Metallurgical Analysis

A brief statement of comparative energy absorption in slow-bend tests is in order. Taking the notched and as-welded condition as unity, the energy absorption after stress relief is of the order of ten times the as-welded condition. Samples without notches absorbed 100 times the energy in the as-welded condition, with as high as 50% elongation and 22% lateral contraction in the outer fibers. Elastic limit was 108,000 psi and ultimate tensile strength was 138,000 psi.

The question of local versus over-all preheating should be settled by a consideration of the thermal stresses caused by the base metal cooling down against possible restraint. In all cases, the entire joint is preheated and an area on both sides included. Where high axial restraint is possible, local preheat would lower the over-all stress on the weld. Without axial restraint, the most economical method should govern. Where high localized restraint is possible, the entire area should be preheated. For example, where an outlet is nozzled into a larger diameter pipe, the entire circumference of the larger pipe should be preheated in order to prevent reaction stresses in the weld area.

The question of preheating vs. postheating can be readily settled. Properties of the weld are established by the weld cooling rate, as determined by joint geometry, welding procedure and preheating. With most arc-welding applications, postheating is not effective as it usually would be applied too late (without preheat) to avoid cracking.

Conclusions and Recommendations

No all-inclusive recommendations are possible because of differences in section thickness, size, restraint, base-metal variations and so forth, but some general statements covering the majority of arc welding of the medium-alloy chrome-moly steels follows.

High stresses and crack sensitivity are encountered with high-temperature differential between weld and base metal, thus calling for moderately high preheats. A preheat at present code levels (450° F) or higher for first pass and manual welding, or a 400° F preheat where higher interpass temperatures would be expected from automatic welding of greater heat input, should be applied.

Low-carbon and low-hydrogen covered electrodes and filler metals should be used. A 500° F interpass temperature should be maintained for the first two passes or one-third the wall thickness. Welding may then be interrupted, but preheat must be restored before resumption of welding.

Postweld treatment consisting of wrapping the weld in an insulating blanket permits delayed cooling to ambient temperature. Thermal stresses arising from temperature

differences in the weld zone are reduced. Reduction of the stress level at any temperature of a cooling weld cycle is reflected in higher notch ductility and crack resistance from that point on. Prolonged heating is to be avoided since secondary hardening and embrittlement can result. Postheating from 500–1000° F introduces secondary hardening and does not increase notch ductility. With high stress levels and secondary hardness, cracks can be propagated while the weld is in the 500° F range and incapable of strain hardening.

The ultimate properties of an otherwise sound welded joint are primarily determined by stress-relief temperature, with time at temperature and cooling rate of lesser but considerable importance. Stress-relief treatment at 1375° F for 1 hr/in. of wall thickness will reduce the hardness to 200 Bhn or under and provide maximum ductility. Slow cooling from stress relieving results in temper embrittlement with a decided reduction in ductility and moderate increase in hardness. Moderately fast cooling of 300 to 500° F per hour is important to reduce temper embrittlement.

Using the above procedures, the author's company has made thousands of welds in medium-alloy chrome-moly steels, subjected to radiography and other nondestructive tests, without a single crack and with excellent ultimate weld properties.

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Corrosion Test Sites Needed

The High Alloys Committee of the Welding Research Council is presently conducting extensive field corrosion tests to determine what industrial process media cause intergranular attack of austenitic stainless steels. To accomplish this, several hundred corrosion-test racks containing welded and unwelded specimens with a variety of heat treatments have been prepared. Two series of test racks, measuring 4 by 4 by 12 in., are being used. One contains molybdenum-bearing alloys (Types 316, 317, etc.); the other, molybdenum-free alloys (Types 304, 310, etc.).

The results of this program should permit a more accurate description of the type of media which cause intergranular corrosion. Also, they will be used to check the boiling 65% nitric acid test as a method for predicting intergranular corrosion susceptibility.

A search for industrial exposure sites is now in progress. Specifically, media which have produced intergranular failure of stainless-steel components are most desirable. Those interested in participating in this program are invited to submit a description of the exposure site to the address below. Specific process details are unnecessary, but a description of solution composition and the local exposure conditions will be required. Upon completion of the exposure, each cooperating group will receive a detailed evaluation of the corrosion-test results.

Interested parties should wire to: R. M. Fuller, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Welding Properties of Chromium-Nickel-Molybdenum Hardenable Stainless Steels

Semiaustenitic hardenable stainless-steel Types AM-350 and AM-355 are found to have excellent weldability by the same techniques and processes that are used for the austenitic stainless steels

BY R. H. KALTENHAUSER

SYNOPSIS. Types AM-350 and AM-355 are semiaustenitic hardenable stainless steels. They were found to have excellent weldability by the same techniques and processes that are used for the austenitic stainless steels. By appropriate low-temperature postweld heat treatments, the weld and base metals may be transformed to a high-strength tempered martensitic structure. Both alloys have welded and hardened strengths equal to 90–100% of the base-metal strengths. The welded joints also possess excellent ductility after hardening.

Since these alloys do not air harden during welding, they have a significant advantage over the martensitic stainless steels. In addition, the hardening of AM-350 and AM-355 is not produced by elements that are generally incompatible to welding in stainless steels, such as aluminum, beryllium, phosphorus or titanium. These two factors give the steels considerably better resistance to hot cracking during welding than other hardenable stainless steels.

The absence of easily oxidizable elements in the alloys, such as titanium and aluminum, helps make them suitable for arc welding. Covered electrodes have been made to deposit the AM-355 analysis. AM-350 and AM-355 bare welding wires are also available for the inert-gas-shielded welding processes.

Introduction

The new family of precipitation-hardening stainless steels have received considerable attention in the past several years and have presented quite a challenge to the welding engineer. The steels may be readily fabricated in the soft and ductile annealed condition and then heat treated to increase their strength and hardness. Alloys of this type include the proprietary alloys Stainless W, HNM, 17–4 pH, 17–7, pH, 17–10 P, 15–7 Mo, V2B, AM-350 and AM-355. They are essentially carefully proportioned chromium-nickel stainless steels containing substantial amounts of alloying elements such as aluminum, beryllium, copper, molybdenum, phosphorus and titanium. In general, the steels have a carefully balanced austenitic structure or are duplex alloys containing austenite and ferrite. The hardening mechanisms may be quite complex and are somewhat different for each alloy. In general, they either involve precipitation hardening, a transformation of austenite to martensite, or a combination of the two. To achieve suitable response to the various hardening treatments, careful control of the chemical composition and heat-treating temperatures is necessary.

The welding processes, which involve wide temperature ranges and possible loss of alloying elements, may result in inadequate response to the hardening treatments. Additional difficulties may be encountered because some of the alloying elements needed for hardening are not ideally suited for welding when present in these steels. The covered-electrode and submerged-arc processes may not be suitable for joining some of these materials due to the low recovery of elements like titanium and aluminum. Other elements, such as phosphorus, have produced cracking problems when present in the stainless steels. Nevertheless, this group of materials has received considerable attention from fabricators in a large cross section of industry. A thorough knowledge of the metallurgical structures produced in these alloys by the welding temperatures is necessary to achieve the optimum properties in welded assemblies. The compositions, metallurgical structures and transformations resulting from heat treating and welding will be examined in detail for two of the alloys in this family.

Chromium-nickel-molybdenum Hardenable Steels

AM-350 is a two-phase or duplex chromium-nickel stainless steel which, in the annealed condition, contains approximately 15% ferrite in an austenitic matrix. The composition is so balanced that, through proper heat treatment, the austenite may be transformed to martensite. Upon tempering, precipitation hardening also takes place, but the major strengthening occurs through the martensitic-phase transformation. In the annealed condition AM-350 has an austenitic matrix with many of the desirable forming characteristics of the austenitic stainless steels. Then, by heat treating at temperatures considerably lower than those required for the martensitic stainless steels, high strengths and hardness may be developed. AM-355 is similar in composition but, in the annealed condition, contains 5% or less delta ferrite in the austenitic matrix. Upon hardening by the same heat treatments as are used on AM-350, slightly higher strength levels may be obtained. The nominal analyses of the two materials are as follows:

Hardening is accomplished by

	%						
Type	C	Mn	Si	Cr	Ni	Mo	N
AM-350	0.10	0.75	0.30	16.25	4.25	2.75	0.10
AM-355	0.13	0.75	0.30	15.25	4.25	2.75	0.10

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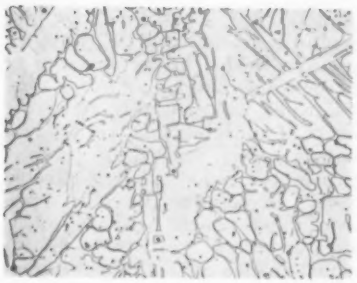

Fig. 1—AM-350 weld metal—as-deposited. Delta ferrite and austenite. 10% ammonium persulfate. × 500. (Reduced by 1/2 upon reproduction)

Fig. 2—AM-350 weld metal hardened by subzero cooling and tempering. Delta ferrite and precipitated carbides in matrix of tempered martensite. 10% ammonium persulfate. × 500. (Reduced by 1/2 upon reproduction)

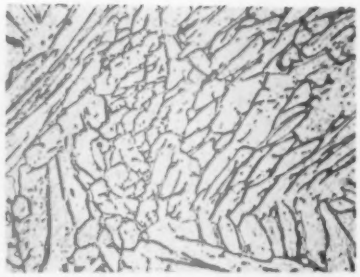

Fig. 3—AM-350 weld metal hardened by double aging. Delta ferrite and precipitated carbides in matrix of tempered martensite. 10% ammonium persulfate. × 500. (Reduced by 1/2 upon reproduction)

cooling below the Ms temperature to produce martensite followed by a tempering treatment which further increases the strength. The following two heat treatments may be employed to achieve hardening:

Annealing Temperature—1710 ± 25° F
Subzero Cooling and Tempering (SCT)
3 hr at −100° F plus 3 hr at 850 to 1000° F
Double Aging (DA)
3 hr at 1375° F, AC to RT maximum plus 3 hr at 850° F

By annealing the material at 1710° F, the Ms temperature will be located near room temperature. Upon subzero cooling to −100° F, the transformation to martensite is effected, subsequent tempering being used to increase strength and toughness. The double aging treatment may also be used for hardening. Treatment at 1375° F causes the precipitation of some carbides in the material and moves the Ms temperature somewhat above room temperature. Upon cooling to room temperature, the transformation takes place. A suitable tempering treatment is then applied.

Effects of Welding Upon the Metallurgical Structure

While all stainless steels are affected by the heat of welding, several additional distinctive effects are apparent when welding AM-350 and AM-355. The high temperatures of welding will increase the amount of delta ferrite in the weld metal and the heat-affected zone of AM-350, thereby reducing the amount of austenite available for transformation to martensite. By postweld annealing at a low temperature to establish a new equilibrium between the austenite and delta ferrite, the amount of delta ferrite will be reduced. Figure 1 shows the as-welded structure of AM-350 in an all-weld-metal deposit made by the consumable-electrode inert-gas process.

There is, however, a more important effect of the high welding temperatures that cannot clearly be illustrated by the metallurgical structures. High temperatures also produce the solution of various alloying elements in the weld metal and heat-affected zone. With a slightly higher effective alloy content in these areas, the Ms temperature is lowered sufficiently that complete transformation of the austenite to martensite will not take place at −100° F. Postweld annealing at 1710° F is thus required to adjust the effective alloy content of the austenite to obtain optimum transformation upon subzero cooling. Figure 2 shows the AM-350 weld metal after annealing at 1710° F, subzero cooling to −100° F and tempering at 850° F.

Hardening may be produced also by an alternate heat treatment. Aging the material for 3 hr at 1375° F will precipitate carbides along the austenite-ferrite interfaces in the AM-350 (and along the austenitic grain boundaries in AM-355). The effective alloy content of the steel has thus been lowered and the Ms temperature has been raised above room temperature. Upon cooling to room temperature, the transformation of austenite to martensite takes place. Figure 3 shows the AM-350 weld metal after aging 3 hr at 1375° F, cooling to room temperature and tempering at 850° F. As a result of the lower effective carbon content, the martensitic structure produced by double aging (DA) has lower strength than the subzero cooled and tempered (SCT) structure.

Although the high welding temperatures do not markedly change the amount of delta ferrite in AM-355, the increased solubility of alloying elements will stabilize the austenite and, therefore, postweld annealing at 1710° F is necessary prior to hardening by either treatment.

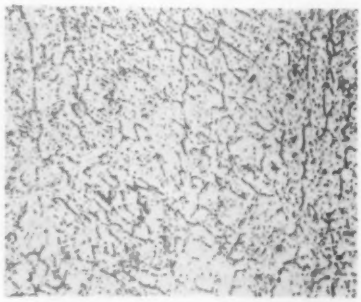

Fig. 4—AM-355 weld metal. Thinly scattered interdendritic delta ferrite and carbide precipitation in matrix of tempered martensite. 10% ammonium persulfate. × 500. (Reduced by 1/3 upon reproduction)

Figure 4 shows the structure of an AM-355 weld made by the inert-gas-shielded tungsten-arc process and hardened as follows:

3 hr at 1375° F, air cooled to room temperature
1 hr at 1710° F
3 hr at −100° F
3 hr at 850° F

The structure contains thinly scattered interdendritic ferrite and precipitated carbides in a matrix of tempered martensite.

The data in Table 1 illustrate the effects of the 1710° F postweld annealing treatment upon the mechanical properties of both alloys.

Weld Filler Metals

For light-gage materials, weld filler metal may or may not be used by the fabricator. If it is not necessary for the weld deposit to be hardened by heat treatment, any austenitic stainless-steel welding wire or electrode may be used to join the steels to themselves or other materials. Other high-alloy weld metals, that have been successfully used on the austenitic stainless steels, may also be utilized when making dissimilar-metal transition welds.

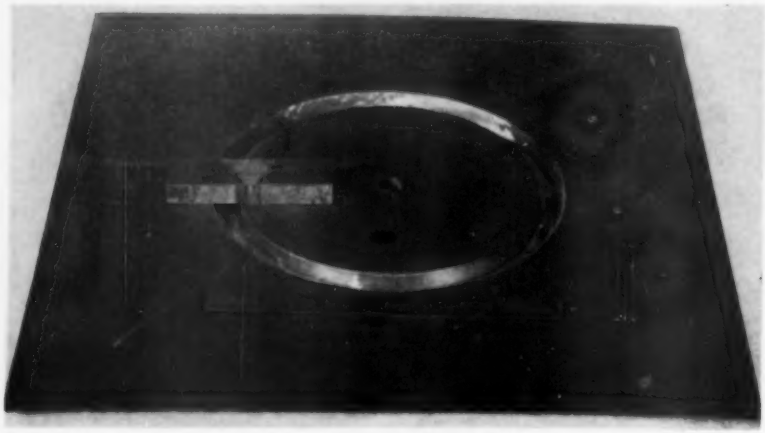

Fig. 5—Circular-groove restrained-weld test on AM-355 plate. Approximately $^{2}/_{3}$ size

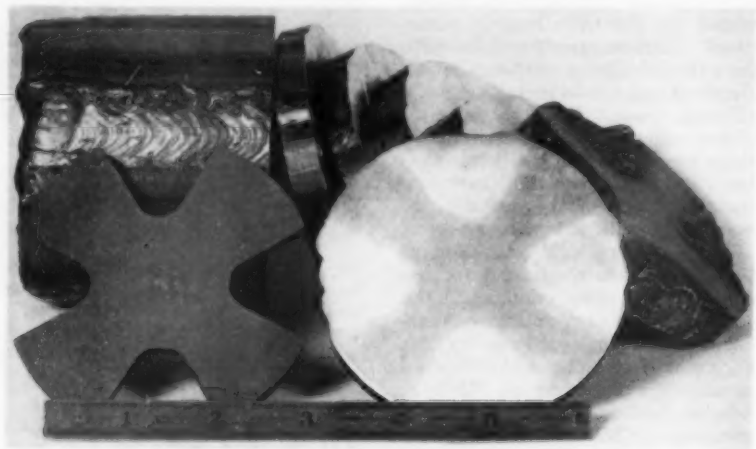

Fig. 6—Cruciform restrained-weld test in hardened AM-355 bar. Approximately $^{1}/_{2}$ size

Table 1—Effects of 1710° F Postweld Annealing Treatment

0.075-in. strip—transversely welded tensile specimens

Material	Heat treatment	0.2% yield strength, psi	Ultimate tensile strength, psi
AM-350	As-welded	83,000	145,000
AM-350	Welded + SCT (850° F)[a]	87,000	148,000
AM-350	Welded + 1710° F + SCT (850° F)	165,000	191,000
AM-355	Welded + SCT (850° F)	73,000	152,000
AM-355	Welded + 1710° F + SCT (850° F)	170,000	203,000
AM-350	Welded + DA[b]	153,000	178,000
AM-350	Welded + 1710° F + DA	160,000	180,000
AM-355	Welded + DA	138,000	184,000
AM-355	Welded + 1710° F + DA	163,000	193,000

[a] Subzero cooling (−100° F) and tempering (as indicated).
[b] Double aging (1375 + 850° F).

AM-350 and AM-355 bare welding wires are available for use when the weld deposits must be hardened by heat treatment. When the highest weld-metal strength is required, AM-355 wire should be used. If maximum corrosion resistance is important, AM-350 wire should be used because of its higher chromium and lower carbon. AM-355 covered electrodes are also available and may be used to weld both alloys.

Preparation of Material for Welding

Cleaning, joint preparation, joint fit-up and jigging procedures for AM-350 and AM-355 are the same as those employed for other austenitic stainless steels. Both steels may be welded in the annealed or hardened condition. Welding temperatures will naturally have the effect of annealing and will produce corresponding mechanical properties in the weld and heat-affected zone. It may be desirable, however, to weld in the hardened condition to reduce the over-all dimensional change of the welded assembly during subsequent hardening of the weld.

Resistance to Weld and Base Metal Hot Cracking

Although these steels may be heat treated to high-strength levels like the martensitic steels, they will not air harden in the weld metal or in the heat-affected zone during welding. The hardenability of AM-350 and AM-355 is produced by a careful balance of alloying elements which include molybdenum rather than copper, aluminum, phosphorus, beryllium or titanium. The latter elements are often incompatible to welding when present in stainless steels. These two factors help give AM-350 and AM-355 excellent resistance to weld-metal hot cracking.

The resistance to weld cracking has been demonstrated by a variety of restrained weld tests on both annealed and fully hardened AM-355. Butt welds have been made on highly restrained AM-355 plates from $^{1}/_{4}$ to 1 in. thickness. Dye-penetrant, radiographic and destructive test methods have not revealed any evidence of base-metal or weld-metal cracking. Welds have been made by the inert-gas tungsten-arc, consumable-electrode inert-gas, covered electrode and submerged-arc welding processes.

Circular-groove restrained-weld tests were made on 0.4- to 0.8-in. thick AM-355 plate by the automatic tungsten-arc inert-gas process using 0.062 in. diam AM-355 filler wire. Figure 5 shows such a test after the first five weld passes had been made. Dye-penetrant inspection was used after each of the first five passes, and X-rays were taken on the completed welds. Side-bend tests were cut from the completed welds and bent to fracture. Examination by all three methods did not reveal any weld- or base-metal cracking.

Several cruciform restrained-weld tests were also made to demonstrate the resistance of AM-355 to weld cracking. The tests were machined from fully hardened AM-355 bars and were welded with both Type 308 stainless and AM-355 covered electrodes. Each groove was com-

pletely welded before proceeding in sequence to the next groove. Figure 6 shows a section from a machined test bar and several sections after completely welding the 6-in. long test bars. Dye-penetrant inspection of the root passes, the remaining unwelded grooves and slices from the completed tests failed to reveal any cracking in the weld or base metal.

Preheating, control of interpass temperature or postweld annealing were not used on any of the forementioned welding tests. The excellent resistance of AM-355 to weld-metal hot cracking precludes the use of these normal precautions. Sound welds with excellent mechanical properties were consistently produced by using the welding techniques common to the austenitic stainless steels.

Heat Treating Welded Material

By utilizing appropriate postweld heat treatments, welded AM-350 and AM-355 may be hardened to obtain weld joint efficiencies of 90 to 100% over a testing temperature range from room temperature to 900° F. Of course, the postweld heat treatments must be selected to obtain the optimum metallurgical properties for both the weld and the base metal.

Like most cast alloys, the metallurgical structures of AM-350 and AM-355 weld deposits are improved by using a postweld homogenizing annealing treatment at 2000° F. Since such a treatment will also promote grain coarsening and will lower the elastic limit in wrought AM-350 and AM-355, high-temperature postweld heat treatments should be used only on welded AM-355 castings.

Forged, rolled, extruded and drawn products must be annealed at 1710° F after welding to condition the weld metal and heat-affected zone for transformation. Heavy sections of AM-355, such as bars, billets and plates, should receive an equalizing heat treatment for 3 hr at 1375° F, air cool to room temperature maximum, prior to the 1710° F annealing treatment. This heat treatment will produce the most desirable metallurgical structure in the steel and will also increase the ductility, elastic limit and impact strength of the alloy. The equalizing treatment is of no significant benefit to AM-350, which appears to respond more quickly to the hardening heat treatments than AM-355.

After annealing at 1710° F, the austenite in both alloys will transform to martensite by heat treating for 3 hr at −100° F. A 3-hr tempering heat treatment between 850 and 1000° F should then be applied to improve further the properties of the steels.

Both steels may also be hardened by the alternate heat treatment—double aging. After welding, AM-350 may be transformed by treating 3 hr at 1375° F, cooling to room temperature maximum and then tempering at 850° F. AM-355 is somewhat more stable and must be annealed at 1710° F after welding and prior to the 1375 and 850° F treatments. Increased strengths may be obtained by cooling below room temperature after the 1375° F treatment.

Table 2 contains tensile data for welded applications using AM-350 strip and AM-355 plate. Other product sizes will produce similar welded properties. The data in the table represent welded strengths of 95 to 100% of the base-metal strength.

Table 2—Typical Welded-and-hardened Tensile Properties

Transversely welded tensile specimens

Material	Hardening treatment	Rc	0.02% yield strength, psi	0.2% yield strength, psi	Ultimate tensile strength, psi	Elongation, %, in 2 in.
AM-350 strip	SCT (850° F)[a]	42	...	162,000	194,000	6
AM-350 strip	SCT (1000° F)	38	...	145,000	165,000	11
AM-350 strip	DA[b]	40	...	135,000	175,000	8
AM-355 plate	SCT (850° F)	43	127,000	171,000	203,000	6
AM-355 plate	(1375° F) SCT (850° F)	44	136,000	173,000	210,000	7
AM-355 plate	(1375° F) SCT (1000° F)	38	132,000	145,000	173,000	12

[a] Subzero cooling (−100° F) and tempering (as indicated).
[b] Double aging (1375 + 850° F).

Resistance Welding

Both alloys may be resistance welded in the annealed or hardened conditions with the same ease as the austenitic stainless steels. Welding conditions normally employed on the austenitic stainless steels are suitable with only minor adjustments in the welding current (or weld cycles) to compensate for the difference in electrical resistivity. Tension shear strengths of hardened plus welded material are of the same general level as material welded and then hardened. By proper selection of electrode size and welding current, the hardened material may be welded without markedly softening the sheet surface over the weld nugget.

Inert-gas-shielded Welding Processes

The inert-gas tungsten-arc process, with and without filler metal, has been successfully used on both materials up to approximately $^3/_8$-in. plate. The inert-gas-shielded consumable-electrode process, using AM-355 bare wire, has been employed for heavier plate sections.

Covered-electrode Welding

The absence of easily oxidizable elements in the alloys makes them suitable for arc welding. Both lime and titania covered electrodes have been made to deposit the AM-355 analysis. Both types perform quite well and the manufacturers have reported no difficulties in producing suitable coating compositions. Although the electrodes are not yet a stock item, several electrode manufacturers have produced small lots upon order.

The AM-355 weld-deposit analysis may be produced by using only a mildly alloyed flux coating on AM-350 core wire. The two alloys differ in composition as shown below:

Type	Carbon, %	Chromium, %
AM-350	0.08–0.12	16.00–17.00
AM-355	0.10–0.15	15.00–16.00

During arc welding, the natural changes in composition from the core wire to the weld deposit bring about a small loss of chromium through oxidation and a small increase in carbon from the coating mixture. These changes bring the original core-wire composition closer to the AM-355 analysis; and with minor adjustments to the coating composition, a weld deposit of the AM-355 analysis may be obtained.

Submerged-arc Welding

AM-355 plates have been successfully joined by the submerged-arc welding process. For the weld deposit to respond fully to the normal hardening heat treatments, its analysis must be the same as the AM-355 bare welding wire. Although the normal commercial submerged-arc welding fluxes for stainless steels are not blended to maintain properly all of the alloying elements in AM-355, manufacturers of the fluxes will blend special mixtures. Several such mixtures are now being investigated.

Filler Wire for Welding Army Ordnance Armor

Research program is conducted to develop a ferritic-steel filler wire with desired strength, ductility, crack resistivity and notch toughness when deposited on manganese-molybdenum armor plate by the inert-gas-shielded metal-arc process

BY S. M. SILVERSTEIN, R. P. SOPHER AND P. J. RIEPPEL

ABSTRACT. Studies were conducted to develop a ferritic-steel filler wire with desired strength, ductility, crack resistivity, and notch toughness when deposited in Army Ordnance Mn-Mo armor plate.

The only commercial filler wire considered to be suitable for welding Ordnance armor was obtained and the mechanical properties of the weld metal determined. Studies were made of experimental filler wires containing misch metal. A Mn-Ni-Mo-V ferritic steel and a Mn-Mo-V ferritic-steel filler wire were developed in this study. Additions of 0.30% misch metal to each of these heats improved the cracking resistance and notch toughness of the weld deposits. The strength and notched-bar properties of the weld metals made with the commercial and experimental filler wires were comparable with mechanical properties of weld metals produced with low-hydrogen covered electrodes of the Grade 260 class. The major improvement of the experimental weld metals as compared with weld metal made with the commercial filler wire was in cracking resistance.

Introduction

At present, austenitic and high-strength low-hydrogen ferritic-steel covered electrodes are most commonly used for welding armor plate. In many applications, the low-hydrogen ferritic electrodes have been used satisfactorily in place of austenitic electrodes. This substitution makes possible conservation of some of the critical alloying elements used in austenitic electrodes. It was believed that further advancements could be made in the welding of armor with ferritic alloys by use of the inert-gas-shielded metal-arc welding process. One of the major advantages of this consumable-electrode process is better control of residual elements in weld deposits than is possible with covered electrodes. A weld metal of controlled composition can be obtained by producing high-purity filler wire and then transferring the metal across an arc which is shielded with an inert gas. It was believed that it would be possible to transfer elements such as misch metal across the welding arc more efficiently by the inert-gas-shielded process. Moreover, the inert-gas-shielded metal-arc process could be used to great advantage in reducing the time required for fabrication of armored vehicles in time of a national emergency.

The object of this research program was to develop a ferritic-steel filler wire with desired strength, ductility, crack resistivity and notch toughness when deposited in Army

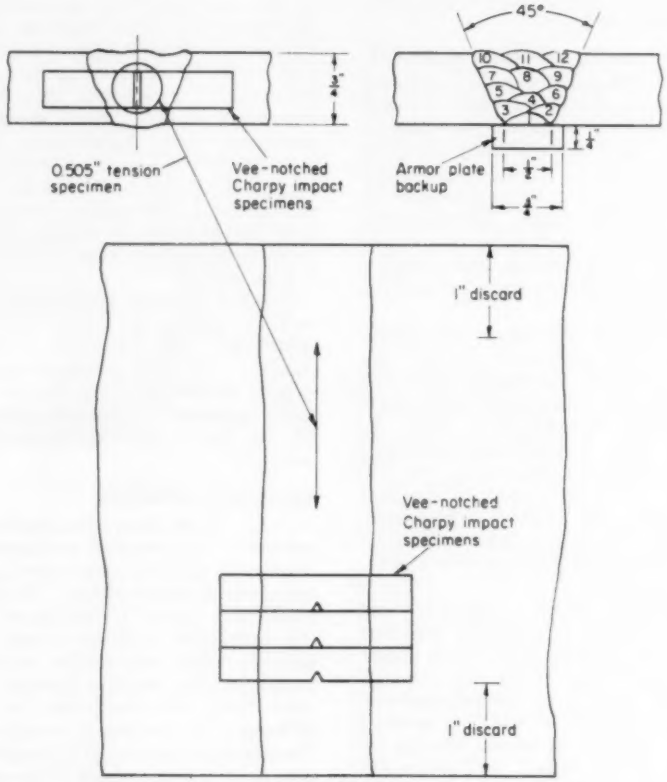

Fig. 1 Joint design, pass sequence and location of tension and impact specimens in a multipass weld

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Ordnance manganese-molybdenum armor plate by the inert-gas-shielded metal-arc process, hereafter referred to as the inert-gas-shielded consumable-electrode process.

The first phase of the program was to procure and evaluate the commercial filler wires that were available. A survey of the wire manufacturers showed that only one ferritic-steel filler wire was available for possible use for welding Ordnance armor. A quantity of this filler wire was obtained and the mechanical properties of the weld metal were determined.

The second phase consisted of the preparation of several experimental filler wires used to produce weld-metal deposits which were evaluated with respect to their mechanical properties. The experimental heats of steel for filler wire were made under carefully controlled conditions so that alloying could be held within close limits. These heats were split into smaller heats and treated with rare-earth metal additions to effect reduction of sulfur content and to determine the effects on cracking resistance and notch toughness. Misch metal was chosen for study because previous investigators have shown beneficial effects with misch-metal additions to cast steels,[1] and other research has indicated that rare-earth additions to a weld metal improved the cracking resistance of the weld metal.[2]

All the experimental heats were forged into bars and rolled into filler wire. The filler wire was then deposited in armor plate by the inert-gas-shielded consumable-electrode welding process. Tension and notch-toughness test data were obtained from specimens machined from butt-joint deposits made with the filler wires. The cracking resistance of the weld metals was determined by modified Lehigh and circular-patch restraint tests.

Commercial Filler Wire

The logical starting point of this research was to determine the properties of the commercial filler wires that were available for welding armor plate by the inert-gas-shielded consumable-electrode process. The only commercial ferritic wire available for welding ordnance armor, although it has not been approved for military applications, was obtained for use in this program. The chemical analysis of the $^1/_{16}$-in.-diam commercial filler wire is shown in Table 1.

Table 1—Chemical Composition, %

C	0.08
Mn	1.33
Si	0.50
P	0.016
S	0.016
Mo	0.42
Ni	1.32
Cr	0.12
V	0.13
Ti	0.02
Al	<0.01

The chemical composition of deposited weld metal was not determined unless so stated in the report. Previous data on the efficiency of alloy transfer across a welding arc shielded with an inert gas showed that the losses which were incurred were within the limits of error of the chemical analysis.[3]

Multipass welds were made with commercial filler wire by the inert-gas-shielded consumable-electrode process in butt joints in $^3/_4$-in. armor plate. The joint geometry was designed to minimize dilution of the weld metal with the base plate. This geometry was a single-vee 45-deg butt joint with a $^1/_2$-in. root opening. A strip of armor from the same heat was used as the backing material. The conditions used to deposit this filler wire were as follows:

1. Wire, $^1/_{16}$-in. diam
2. Travel speed, 13 ipm
3. Gas, argon + 2% oxygen, 75 cfh
4. Polarity, d-c reverse
5. Current, 300 to 305 amp
6. Voltage, 27 to 29 v
7. Heat input, 39,180 joules/in. of travel

All of the weldments were radiographed for weld soundness prior to machining the test specimens. Tension and vee-notched Charpy impact specimens were machined from the weldments. The pass sequence and the orientation of the test specimens taken from the weldments are shown in Fig. 1.

Data obtained from standard 0.505-in. tension specimens showed that the as-deposited commercial filler wire had a 100,000-psi yield strength, 120,000 - psi tensile strength, 23% elongation over a 2-in. gage length and 46% reduction in area.

The data obtained from the tests of vee-notched Charpy impact specimens were: 42 ft-lb at 0° F, 24

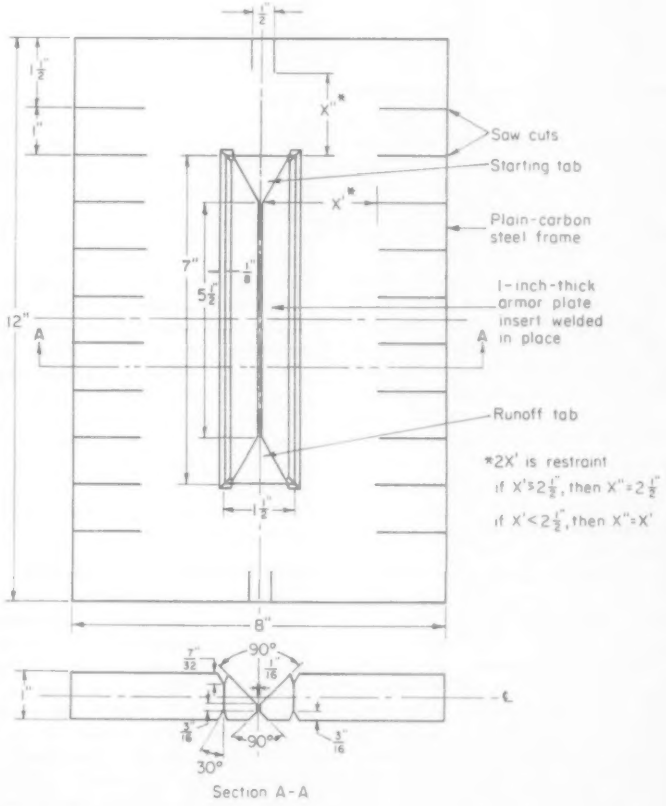

Fig. 2 Restrained weld-cracking specimen

ft-lb at −40° F and 16 ft-lb at −65° F.

Two types of test specimens were used to determine the susceptibility of the weld deposit to weld-metal cracking. One type of specimen was a modified Lehigh-restraint weld-cracking specimen. A diagram of this specimen is shown in Fig. 2. The modified Lehigh restraint specimen consists of two parts, a rigid frame and inserts. With this specimen, the restraint in the weld may be varied by changing the distance X of Fig. 2. As X is increased, the restraint is increased. Sufficient tests were made to determine the smallest $2X$ dimension or degree of restraint that would cause cracking for each weld-metal composition studied. The more crack-sensitive weld-metal composition would be associated with the smaller degree of restraint necessary for crack formation.

The material initially used as inserts for these tests was 1-in. thick Army Ordnance rolled homogeneous armor plate of the composition given in Table 2.

Table 2—Chemical Composition, %

C	0.24
Mn	1.53
Si	0.17
P	0.021
S	0.017
Mo	0.50

This armor had a yield strength of 157,000 psi, a tensile strength of 168,000 psi, an elongation of 10% over an 8-in. gage length and conformed to the requirements of Specification MIL-A-12560.

The commercial filler wire was deposited as a one-pass root weld with the inert-gas-shielded consumable-electrode welding process in a series of Lehigh specimens to determine the resistance to cracking. The commercial weld metal was capable of withstanding 8 in. of restraint. However, several hours after welding, cracks occurred in all the specimens. The cracks appeared to have initiated in the heat-affected zone at the root of the weld joint. These cracks then progressed either in the heat-affected zone or along the bond line to the surface of the weld. The mechanism of failure is not known. However, on the basis of other studies,[4] it may possibly be caused by the migration of hydrogen (initially in plate or filler wire) into highly stressed areas near the weld deposit, which then gives a condition analogous to underbead cracking. This general type of cracking often has been termed nose cracking.

The circular-patch specimen was the other test used in this investigation to establish the crack susceptibility of the commercial weld metal. A new heat of 1-in. thick Army Ordnance rolled homogeneous armor plate was used in the fabrication of these specimens. This change was made in an attempt to reduce the problem of nose cracking. The composition of this armor is given in Table 3.

Table 3—Chemical Composition, %

C	0.29
Mn	1.81
Si	0.18
P	0.017
S	0.016
Ni	0.12
Cr	0.09
Mo	0.52

The armor also conformed to the requirements of Specification MIL-A-12560. This heat of armor, which was used to replace the armor used in the Lehigh tests, did not appear to be susceptible to nose cracking. A diagram of a circular-patch specimen is shown in Fig. 3. The specimens were machined with various patch diameters, D. These specimens were used to determine the maximum degree of restraint at which the deposited weld metal would not crack. The degree of restraint is increased by decreasing the diameter of the patch while keeping the outside dimensions of the specimens constant. The root pass was made on one complete revolution of the specimen. Deposition of the commercial filler wire by the inert-gas-shielded consumable-electrode process showed that a root pass did not crack when deposited in a 5-in. diam patch specimen. However, a weld deposit made with this filler wire did crack when deposited in a 4-in. diam specimen. Thus, on the basis of these two tests, the level of restraint which the deposited commercial filler wire could withstand without cracking was 5 in.

Experimental Filler Wires

Several experimental heats of steel were prepared in an attempt to develop improved filler wires for welding Ordnance armor. This investigation included a study of the effects of misch metal and other alloying elements present in a low-alloy ferritic steel. The heats were made under carefully controlled conditions in a MgO-lined electric induction furnace. The additions to the heat were made from high-grade melting stock and alloying compounds. The chemical composition of each of the additions was known prior to the preparation of the heats. The exact amount of each element added to the melt of steel was predetermined and extreme care was used in weighing these materials. All additions were made in the furnace. The steels used in this program were melted under an inert atmosphere of argon to minimize the loss of alloying elements in the steel through oxidation. Big-end-up ingot molds were used for all the experimental heats. The size of the experimental heats was varied from 111-lb heats, which were subsequently divided into three 37-lb ingots, to 300-lb heats, which were divided into three 100-lb ingots. The reason for dividing the heats was to determine the effects of element additions on properties of the weld metals. The variations in the sizes of the initial heats were determined by the amount of filler wires required for deposition and subsequent mechanical testing.

Approximately 0.03% aluminum was added as a deoxidizer to the base heats which were subsequently split for misch-metal studies. This procedure was followed to prevent a loss of misch metal through oxidation. Those heats which contained misch metal were poured as close to 2850° F as possible because maximum desulfurization of steel results when misch metal is added at this temperature. The heat of steel was poured immediately after the misch-metal addition, in order to obtain the maximum benefit of the misch metal.[1] The normal pouring temperature for heats without misch metal was 2900 and 2880° F.

In order to get a representative chemical analysis of the ingots containing misch metal, the sample was taken 1/4 in. below the surface and 2 in. below the hot top of the ingot. This was done to prevent the inclusion of material from the ingot surfaces which was high in misch-metal sulfide. The high sulfide content is caused by misch-metal sulfide rising and freezing at the surfaces and top of the ingot.

Effect of Rare-earth-metal Additions on the Properties of Weld Metals

Prior to the preparation of heats containing rare earths, a survey was made to determine the effects of these additions to steel. It was found that rare-earth additions (of over 5 lb per ton) to steels produced in a basic crucible, reduced the sulfur content of the original heat approximately 50%.[1] The search also

indicated that the additions of rare earths to steel castings reduced hot tearing, which is believed to be analogous to hot cracking in a weld metal. On the basis of this prior work, a program was initiated to determine whether misch metal in a filler wire would transfer across a welding arc and, if so, what percentage of the rare-earth metal was transferred as compared with the original addition made to the heat of steel. It was believed that if misch metal could be transferred across an arc, an excess of the rare-earth metals in the filler wire not only would form a more favorable type of inclusion in the filler wire but also would control the sulfur from that portion of the base plate that diluted the weld-metal pool. Two heats of Mn-Ni-Mo-Cr steel with 6 lb/ton and 10 lb/ton of added misch metal were used in a study to determine the amount of misch metal that could be transferred across a welding arc.

The experimental steels were drawn into $^1/_{16}$-in. diam filler wire and deposited by the argon-shielded consumable-electrode process into weld pads. Spectrographic and chemical analyses were made to determine the total misch metal and total sulfur contents, respectively. The analyses of the original heats, filler wires and weld deposits are given in Table 4.

Table 4

Heat No.	Sulfur in original melt prior to the addition of misch metal, %	Misch metal added to melt, %*	Sulfur in final melt, %	Misch metal in final melt, %
1	0.042	0.30	0.018	0.060
2	0.022	0.50	0.014	0.149

Heat No.	Sulfur in weld pad, %	Misch metal weld pad, %
1	0.022	0.027
2	0.011	0.016

* Converted from pounds per ton.

There was considerable loss of misch metal across the welding arc. By comparing the boiling points of lanthanum (3275° F) and cerium (2550° F), which are the two primary constituents of misch metal, with that of iron (4960° F) it is possible that some of the loss may have occurred by vaporization in the welding arc. However, the presence of sulfur could lower the activity of the misch metal and consequently lower the vapor pressure. The resulting increase in boiling point should permit a more efficient transfer of misch metal

Table 5—Composition of Filler Wires and Mechanical Properties of Weld Metals Deposited from These Filler Wires

Designation	Added misch metal	Chemical composition, %* C	Mn	Si	P	S	Mo	Ni	Cr	V	Ti	Al	Tensile properties† Yield strength, 1000 psi	Ultimate tensile strength, 1000 psi	Elongation in 2 in., %	Reduction in area, %	Vee-notched Charpy impact values, ft-lb‡ 78° F	0° F	−40° F	−65° F	Crack resistivity maximum restraint, in. Lehigh test	Circular-patch test
Commercial filler wire	..	0.08	1.33	0.50	0.016	0.016	0.42	1.32	0.12	0.13	0.02	0.01	100	120	23	46	..	42	24	16	8	5
Misch Metal Studies																						
Heat B	..					0.024	..	..	..	..	..	..	..	..	..	..	12	5	3	3	..	..
Heat C	Split heat of Mn-Mo-V steel 0.30					0.022	..	..	..	..	..	..	..	..	..	..	16	9	7	4	..	..
Mn-Ni-Mo-V steels§																						
Heat D	Split ..	0.05	1.52	0.53	0.007	0.035	0.70	1.39	..	0.11	0.07	0.04	105	110	6	14	18	13	6	..	6	..
Heat E	heat 0.15	..	..	..	..	0.032	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	..
Heat F	0.30	..	..	..	..	0.015	..	..	0.63	..	..	..	116	127	14	31	..	>70	33	21	8	4
Heat G	0.30	0.05	1.49	0.84	0.010	0.016	0.71	1.10	0.60	0.11	0.14	0.03	118	128	10	20	25	14	..	..	..	..
Heat H	0.30	0.07	1.43	0.54	0.009	0.019	0.48	1.38	0.59	0.10	0.07	0.02	115	124	10	18	35	25	17	10	8	3
Mn-Mo-V steels§																						
Heat L	Split ..	0.04	1.85	0.38	0.008	0.030	0.47	..	..	0.12	0.03	0.03	..	..	..	..	..	24	15	10	8	4
Heat M	heat 0.15	..	..	..	..	0.022	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
Heat N	0.30	..	..	..	..	0.016	..	..	..	..	..	..	111	111	19	42	..	34	25	20	8	3
Heat P	0.30	0.07	1.75	0.44	0.009	0.019	0.43	..	0.24	0.10	0.07	0.03	110	114	15	28	39	25	19	17	8	4

* Filler-wire analysis.
† Each value is the average of two tests.
‡ Each value is the average of two or more tests.
§ The analyses of all the split heats were made for one split only, with the exception of the elements which were varied.

through the welding arc. Another observation was that the amount of misch metal found in the weld metals was proportional to the sulfur contents. However, inasmuch as misch metal does not appear as a discrete sulfide in molten steel, one would not expect to find discrete sulfides in the welding arc.

An advantage gained from the use of misch metal in steels is its influence on the solidification of the sulfides. It was observed that the rare-earth sulfides tend to rise to the top and surfaces of an ingot. This indicates that freezing and precipitation of the sulfides occur very early in the solidification process, which is different from the mechanism of freezing of FeS and MnS which occurs at the grain boundaries. As a result of the early precipitation of the rare-earth sulfides, it has been shown in other work that the cracking resistance of weld metals can be improved.[3] This was demonstrated by comparing the cracking resistance of two weld metals of equal sulfur content, one with no misch metal and the other with misch metal.

In order to determine the effects of misch metal on the notch toughness of a weld deposit, a heat of Mn-Mo-V steel fully killed with aluminum was made and split into two smaller heats. The first split (Heat B, Table 5), was a medium-sulfur steel (0.024%). Iron sulfide was then added to the base heat to produce a high-sulfur content of approximately 0.040%; 0.30% of misch metal then was added to reduce the sulfur content to approximately the same level as the first heat, as shown in Heat C. It was believed that the effects of misch-metal additions on notch toughness could be determined by comparing the properties of weld metals deposited with the two compositions of medium-sulfur weld metals, i.e., one without misch metal and the second of initial high-sulfur content which was reduced by misch metal to an equivalent medium sulfur.

The two heats of steel were hot forged at 2200° F to $^3/_4$-in. bar. These bars were hot rolled to $^1/_4$-in. rod and then cold rolled to $^3/_{32}$-in. square filler wire. These wires then were deposited by the inert-gas-shielded consumable-electrode process in armor plate. The joint geometry of the welded specimens and the orientation of the vee-notched Charpy impact specimens obtained from the weldments are shown in Fig. 1. The data obtained from testing the impact

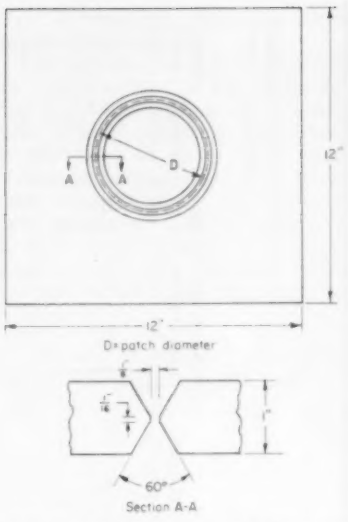

Fig. 3 Details of circular-patch specimen used to determine crack resistivity

specimens over a range of temperatures showed that weld metals containing misch metal exhibited slightly (approximately 4 ft-lb) higher impact energy than weld metals of the same chemical composition without misch metal.

Tests also were made to determine the effects of misch metal on the crack resistivity of the weld metals. Two heats of steel, one a Mn-Ni-Mo-V steel and the other a Mn-Mo-V steel, were made and split into three smaller heats (D, E and F and L, M and N of Table 5). The first split of each heat contained no misch metal. The second heat contained 0.15% misch metal and the third heat contained 0.30% misch metal. These additions reduced the sulfur content of the second and third heats from an average of 0.030% sulfur to an average of 0.027 and 0.015% sulfur, respectively. These heats of steel were fabricated into filler wire. The filler wires were then deposited by the inert-gas-shielded consumable-electrode process into modified Lehigh and circular-patch specimens which were described previously and shown in Figs. 2 and 3. It was found for the Mn-Ni-Mo-V steel that those splits containing misch metal withstood the high restraint (8 in.), which is the maximum offered by Lehigh test; while the weld metal with no misch metal withstood only 6 in. or medium restraint.

All the weld metals of the Mn-Mo-V steel withstood the maximum restraint offered by the modified Lehigh restraint specimen. Therefore, in order to differentiate between the crack resistivity of these splits of steel, the circular-patch test was used because it appeared to offer a greater degree of restraint than the Lehigh test. Those weld metals which contained misch metal withstood the restraint offered by a 3-in. diam patch in a 12 by 12 by 1-in. frame, while the weld metal from the split which contained no misch metal failed when deposited in a 3-in. diam specimen.

These test results indicated that additions of misch metal improve the cracking resistance of a weld metal, even though the sulfur content is not greatly reduced (approximately 0.005% reduction in sulfur for a 0.15% addition of misch metal). Again this improvement may be the result of the prior freezing and precipitation of the rare-earth sulfides, which was discussed previously.

Studies of Mn-Ni-Mc-V Weld Metals

Attempts were made to improve the properties of the existing commercial filler wire by making heats with small variations in chemical composition. In formulating the new heats, it was believed that the carbon should be kept low since an increase in the carbon content of pearlitic steels generally increases the temperature at which transition from ductile to brittle behavior takes place.[5] Although this previous work was conducted with pearlitic steels, it was believed that the information could be used in designing the compositions discussed in this study. Also, a low-carbon content would tend to reduce the effects of temper brittleness if this material were to be stress relieved.[6]

It was believed that the manganese content of the commercial filler wire should be increased slightly, since this should improve the impact strength of the steel[5] and also regain some of the strength lost by the reduction of the carbon content.[7] Another modification was made also to reaffirm the effect of misch metal in reducing sulfur. It was decided to make the sulfur content of the base heat higher than that of the commercial heat, and then reduce the sulfur by additions of misch metal to splits of the base heat. The molybdenum content of the new heat also was raised to compensate for the loss in strength caused by the reduced carbon content.[7] The chromium content of the new heat of steel was increased slightly over that of the commercial filler wire to increase the hardenability of the weld metal.[8] The remaining alloy-

ing elements in the experimental heat were kept essentially the same, percentagewise, as those in the commercial filler wire.

A 111-lb heat of this formulated experimental steel was made under the carefully controlled conditions described previously and split into three smaller heats. Three pounds of misch metal were added per ton of steel to the second split and 6 lb of misch metal were added per ton of steel to the third split. The chemical compositions of the splits are given in Table 6.

Table 6—Chemical Composition, %

Heat	C	Mn	Si	P	S	Mo	V	Ti	Cr	Ni	Al	Added misch metal
D	0.05	1.52	0.53	0.007	0.035	0.70	0.11	0.07	..	1.39	0.04	..
E	..	..	..	..	0.032	..	..	..	..	..	..	0.15
F	..	..	..	..	0.015	..	..	..	0.63	..	..	0.30

The experimental heats were hot forged at 2250° F and then hot rolled to $^1/_4$-in. square rod. The $^1/_4$-in. rod was heated to 1550° F for $^1/_2$ hr, air cooled and cold rolled to $^3/_{32}$-in. square wire. Multipass welds were made with the D and F filler wire using the inert-gas-shielded consumable-electrode process. The heat of steel containing 0.15% misch metal was not used because it was believed the weld metals from Heats D and F would better illustrate the differences in properties. All-weld-metal tension and impact specimens were machined from the deposits (see Fig. 1). The results of testing these specimens are given in Table 7.

The increased strength, slightly greater tensile ductility and improved impact values of Heat F, as compared with Heat D, may be attributed largely to the decreased sulfur content. Although there was a difference in chromium content of the two weld metals (D-residual and F, 0.63%), it is believed that it would not account for the difference in notch-toughness properties.[5]

The misch-metal additions may have changed the types of inclusions, which may have contributed to the improved properties. However, metallographic studies on the tested specimens did not show any real difference in inclusion types between the two weld metals. If a difference did exist, it would have been difficult to detect because the structure of the deposits was complex as a result of the fine and coarse structures produced by multipass welding.

Single root passes of experimental filler wires D and F were deposited under various degrees of restraint in the Lehigh test specimen. Weld deposits made with the D wire withstood a restraint of 6 in. but cracked when deposited in a 7-in. restraint specimen. The F wire withstood the maximum restraint offered by the Lehigh test (8 in.). This improvement may be attributed to the decreased sulfur content as a result of the addition of misch metal and/or the formation of high-melting-point rare-earth metal sulfides.

Since the commercial filler wire and the F experimental filler wire withstood the 8 in. of restraint offered by the Lehigh test, a comparison of these wires was made by using the circular-patch specimen. A root pass of experimental filler wire F deposited in a 3-in. diam patch cracked, while no cracks occurred with a 4-in. diam patch. This test result indicates that experimental wire F is less crack sensitive than the commercial filler wire which cracked when deposited in a 4-in. diam patch specimen.

Perhaps one reason for the lower tensile ductility of the experimental weld metals as compared with commercial weld metal is the difference in size of filler wire. The experimental wire was $^3/_{32}$-in. diam while the commercial wire was $^1/_{16}$-in. diam; as a result, fewer passes for a given joint design were required with the larger diameter wire. With fewer passes, there was less grain refinement, which might account for the lower tensile ductility. Unfortunately, the expense for producing the $^1/_{16}$-in. wires was prohibitive and for this reason $^3/_{32}$-in. diam filler wires were used.

It was necessary to reproduce the best heat (Heat F), because the amount of material in the original heat was insufficient for complete evaluation. Therefore, an additional 100-lb heat of Mn-Ni-Mo-V steel (Heat G) was made. This heat of steel, made under the carefully controlled conditions specified previously, had the following chemical composition (Heat F is listed again for comparison purposes in Table 8).

Table 8—Chemical Composition, %

Heat	C	Mn	Si	P	S	Mo	Ni	Cr	V	Ti	Al	Added misch metal
F	0.05	1.52	0.53	0.007	0.015	0.70	1.39	0.63	0.11	0.07	0.04	0.30
G	0.05	1.49	0.84	0.010	0.016	0.71	1.10	0.60	0.11	0.14	0.03	0.30

The major difference between the composition of the two heats was the increase in silicon and titanium and the decrease in nickel content. Tension and impact tests made on weld metals of the deposited filler wires of Heat G showed a considerable decrease in impact properties and a slight decrease in ductility when compared with Heat F, as shown in Table 5. These results seem to indicate the necessity of maintaining close control of chemical composition, if the properties of a weld metal are to be duplicated. The increased silicon and titanium as well as the decreased nickel may have aided in decreasing the impact properties of the weld metal.[5]

A second attempt was made to produce a heat similar to Heat F except that the molybdenum content of this heat was decreased from

Table 7—Tension Tests*

Heat	Yield strength, psi	Ultimate tensile strength, psi	Elongation in 2 in., %	Reduction in area, %
D, no misch metal	105,000	110,000	6	13
F, 0.30% misch metal	116,000	126,000	14	31

Impact Tests†

Heat	(Vee-notched Charpy impact values, ft-lb) 78° F	0° F	−40° F	−65° F
D	18	13	6	..
F	..	70	33	21

* Each value is the average of two tests.
† Each value is the average of two or more tests.

0.70 to 0.48%. The chemical composition of the new 37-lb heat was as follows:

Heat	H
C	0.07
Mn	1.43
Si	0.54
P	0.009
S	0.019
Mo	0.48
Ni	1.38
Cr	0.59
V	0.10
Ti	0.07
Al	0.02
Added misch metal	0.30

Tension and impact tests were made of all-weld-metal specimens from Heat H filler wire. The results are as follows:

Filler wire	Heat H
Yield strength, psi	115,000
Ultimate tensile strength, psi	124,000
Elongation, in 2 in., %	10
Reduction in area, %	18
Vee-notched Charpy impact values, ft-lb	
78° F	35
0° F	25
−40° F	17
−65° F	10

These results are somewhat better than those obtained from the testing of the Heat-G weld metal, but are lower than the properties of the Heat-F weld metal.

Crack-sensitivity tests showed that the weld metal of Heat H was capable of withstanding the maximum restraint of 8 in. offered by the Lehigh specimen. This material also showed no cracks when deposited in a 3-in. diam circular-patch specimen. Both of these conditions are considered to impart severe restraint on a weld deposit.

Studies of Mn-Mo-V Weld Metals

The second type of steel chosen for study in this research program was a Mn-Mo-V steel. The chemical composition of this filler wire, once again, was patterned after the composition of the commercial filler wire. However, nickel and chromium were not added to the new heat, and the manganese content of this material was increased to improve the notch toughness and compensate for the removal of nickel.[5]

A 300-lb heat of this new steel was made under carefully controlled conditions and divided into three smaller heats (100 lb each). This heat was split in order to observe, once again, the effect of misch metal on reducing the sulfur content and also on increasing impact properties. No misch metal was added to the first 100-lb heat, 0.15% was added to the second and 0.30% was added to the third. Samples taken 2 in. below the hot top of each ingot and 1/4 in. below the ingot surface were analyzed with the results given in Table 9.

Table 9—Chemical Composition, %

Heat		C	Mn	Si	P	S	Mo	V	Ti	Al	Added misch metal
L	Split	0.04	1.85	0.38	0.008	0.030	0.47	0.12	0.03	0.03	..
M	Heat	..	..	..	..	0.022	..	..	..	..	0.15
N		..	..	..	..	0.016	..	..	..	..	0.30

It is shown that an addition of 6 lb of misch metal to a ton of a 0.030% sulfur steel reduced the sulfur content of the steel to about 0.015%. The three ingots were forged and rolled into filler wire. These wires deposited in armor plate by the inert-gas-shielded consumable-electrode process. Tension tests were made on the as-deposited weld metal of Heat N only, since previous work on this project has indicated that the sulfur content in the range encompassed in this work has little effect on the strength properties of a steel. However, impact tests were made on weld metals deposited from Heats L and N.

The results of the impact tests of Heats L and N are shown in Table 10.

Table 10

Heat	Yield* strength, psi	Ultimate tensile strength, psi	Elongation in 2 in., %	Reduction in area, %	Vee-notch Charpy impact values, ft-lb 0 °F	−40° F	−65° F
L	...	...	..	..	24	15	10
N	111,000	111,000	19	42	34	25	20

* Average of three tests.

These data show that misch-metal additions to a steel containing 0.030% sulfur improved the impact properties of weld metals deposited with filler wire fabricated from this steel. This improvement probably was affected by a combination of misch metal and low-sulfur content. The yield and ultimate tensile strengths of Heat N weld metal were the same; however, the material was far from being brittle. It appears that the weld metal was unable to work harden to any great degree.

The crack sensitivity of the two weld metals containing 0.030 and 0.016% sulfur (Heats L and N, respectively) was determined with the circular-patch test. The low-sulfur weld metal did not crack when deposited in a 3-in. diam circular-patch specimen, while the high-sulfur weld metal cracked under this restraint. Lehigh restraint tests did not detect this difference in cracking resistance in that both wires withstood the maximum restraint offered by the Lehigh specimen.

Heat N appeared to have excellent mechanical properties, although there was no difference between the yield-point strength and the ultimate tensile strength of this material. However, an additional heat of Mn-Mo-V steel was made with slight variations in the chemical composition to improve the ultimate tensile strength of the weld metal. Chromium was added to this heat to increase the hardenability of the weld metal.[5] The composition of the new 37-lb heat is given in Table 11.

Table 11—Chemical Composition, %

Heat	P
C	0.07
Mn	1.75
Si	0.44
P	0.009
S	0.019
Mo	0.43
Cr	0.24
V	0.10
Ti	0.07
Al	0.03
Added misch metal	0.30

This heat of steel was fabricated into 3/32-in. filler wire and deposited by the inert-gas-shielded consumable-electrode process in armor plate. Tension and impact specimens were then machined from the weldment, as shown in Fig. 1. The results obtained from testing the tension and impact specimens are given in Table 12.

Table 12

Heat	P
Yield strength, psi	110,000
Ultimate tensile strength, psi	114,000
Elongation in 2 in., %	15
Reduction in area, %	28
Vee-notched Charpy impact values, ft-lb	
75° F	39
0° F	25
−40° F	19
−65° F	17

As can be seen from the above data, the addition of chromium to Heat P improved the ultimate tensile strength of the weld metal over that of Heat N. However, the tensile ductility and impact properties were lowered slightly. This decrease might be attributed to minor differences in chemical composition such as the decrease in manganese and increase in titanium contents. These variations were not anticipated. Crack-sensitivity tests showed that the P filler wire was capable of withstanding severe restraint as determined by the Lehigh restraint specimen (8 in. of restraint). This filler wire also was deposited in a 12- by 12-in. frame with a 4-in. diam patch without cracking.

Discussion of Results

Weld metals deposited from experimental filler wires developed in this research program have strengths which are equivalent to the strength of a weld deposit of a Grade 260 covered electrode.[9] The Mn-Ni-Mo-V weld deposit (Heat H) has a 20% lower reduction in area yet exhibits equally good impact properties when compared with a Grade 260 weld metal. The experimental Mn-Mo-V weld metal (Heat P) showed 15% better tensile ductility than the Mn-Ni-Mo-V weld metal, but had a slightly lower ductility than the Grade 260 class of weld metals. At −65° F test temperature, the notch toughness of the Mn-Mo-V experimental weld metal was 8 ft-lb higher than the notch toughness of Grade 260 weld metals. However, the major improvement of these experimental filler wires compared with weld metals made from Grade 260 electrodes appears to be their increased cracking-resistance properties. No preheat was used in determining the cracking resistance of the experimental weld metals with the circular-patch specimens. Even under these conditions the Mn-Ni-Mo-V filler wire (Heat H) and the Mn-Mo-V filler wire (Heat P) withstood severe restraints without cracking. It is believed that this shows a significant improvement over the Grade 260 weld metal, because most of the specifications which include this class of electrodes designate the use of a preheat. However, the cracking resistance of the E12015 weld metal was not available and, as a result, no direct comparison could be made between this weld metal and any of the deposits made with the experimental filler wires.

The research in this investigation has shown that a misch-metal addition to a heat of steel not only reduces the sulfur content in the steel but also increases the notch toughness and crack resistivity of the weld metal deposited from the steel. Sulfur reduction in a steel can be affected by other means such as utilizing high-quality melting stock or by the double-slag method used in the basic electric furnace. However, it is not only the reduction in sulfur which gives the steel these improved properties. It has been shown that misch metal improves the impact properties of a weld metal whether it is high or low in sulfur content. Misch metal also improves the cracking resistance of the weld deposits by causing early freezing of the sulfides in the weld pool as compared with the solidification of residual eutectics that normally occur in steel.

The results from the investigation indicate that filler wires for use with the inert-gas-shielded consumable-electrode process may be produced to deposit weld metals with strength and toughness properties which are comparable with the properties of weld metal deposited with low-hydrogen ferritic-steel covered electrodes. In addition, the cracking resistance of the weld metals deposited with the experimental filler wires was higher when compared with weld metals deposited with the commercial filler wire. Acceptance of these filler wires for welding armor plate would require ballistic testing of weldments fabricated with these experimental wires.

The use of the inert-gas-shielded consumable-electrode process could decrease the time required for the fabrication of many of the armored vehicles where a heavy weld and long continuous joints are used. However, additional development work is needed to establish the optimum joint design and welding procedures for this process.

Summary

The notch toughness of the weld metal deposited with the commercial filler wire was somewhat lower than that of weld metals deposited with low-hydrogen covered electrodes of the commercial E10016 class. However, the toughness of weld deposits made with the filler wire was slightly higher than that of weld metals of the E12015 class studied previously.[9]

The weld deposits made with the experimental filler wires containing misch metal exhibited better crack resistance than deposits made with the commercial filler wire, as shown by Heats F, H, M, N and P of Table 5. In addition, the test results obtained from the studies of rare-earth metal additions to the filler wire indicated that: (1) the sulfur content of a weld metal could be reduced from 0.030% to approximately 0.015% by an addition of 6 lb/ton of misch metal, as shown by Heats D and F, and Heats L and N, of Table 5; and (2) in spite of the fact that a considerable amount of misch metal was lost during transfer across the welding arc, the notch toughness of the weld metals could be improved, as shown by Heats B and C, Heats D and F and Heats L and N.

Of the experimental filler wires developed in this study, two types appeared to show the most promise for welding armor by the inert-gas-shielded consumable-electrode process. One type was a Mn-Ni-Mo-V ferritic steel and the other was a Mn-Mo-V ferritic steel. Additions of 0.30% misch metal were made to each of these experimental heats.

A comparison of the mechanical properties of the experimental Mn-Ni-Mo-V weld metal (Heat F) with the commercial weld metal showed that the experimental weld metal had the higher ultimate tensile strength and notch toughness. However, the tensile ductility of this experimental weld metal was lower than that of the commercial weld metal. The Mn-Mo-V weld metal (Heat N), when compared with the commercial weld metal, had a lower ultimate tensile strength; however, the notch-toughness and tensile ductility properties were similar. The major improvement of the experimental weld metals over the commercial weld metal was the increase in cracking resistance.

In several attempts to reproduce the experimental filler wires, it was found that small variations in chemical composition resulted in large differences in mechanical properties. These differences in properties indicate the necessity for very close control in the preparation of heats of these compositions and the need for further research to deter-

mine the effects of small individually controlled alloy additions.

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External Loadings on Pressure Vessels

by P. P. Bijlaard

Welding Research Council Bulletin No. 50 to be published in May 1959 contains two papers describing theoretical work done on the calculations of stresses resulting from external radial and bending moment loadings on pressure vessels. These papers describe research investigations carried out at Cornell University under the sponsorship of the Pressure Vessel Research Committee of the Welding Research Council. The Subcommittee on External Loadings on Pressure Vessels assisted Prof. Bijlaard in guiding this work. Single copies may be purchased through the American Welding Society, 33 W. 39th St., New York 18, N. Y. Quantity lots may be purchased through the Welding Research Council, 29 W. 39th St., New York 18, N. Y.

The titles and summaries of the two papers comprising Bulletin No. 50 are given below to inform design engineers of the objectives and scope of these research investigations.

"Stresses in Spherical Vessels from Local Loads Transferred by a Pipe"—Summary—A method is presented for computing the stresses in a spherical vessel from radial loads and external moments transferred by a pipe, taking account of the radius and wall thickness of the pipe and of a reinforcing pad on the vessel. Also other kinds of local loadings on a spherical vessel are reviewed.

"Additional Data on Stresses in Cylindrical Shells Under Local Loading"—Summary—Graphs are presented for the bending moments and membrane forces in cylindrical vessels, subject to radial load or external moments, at the edge and away from the loading surface. Simple design rules are given for using these graphs.

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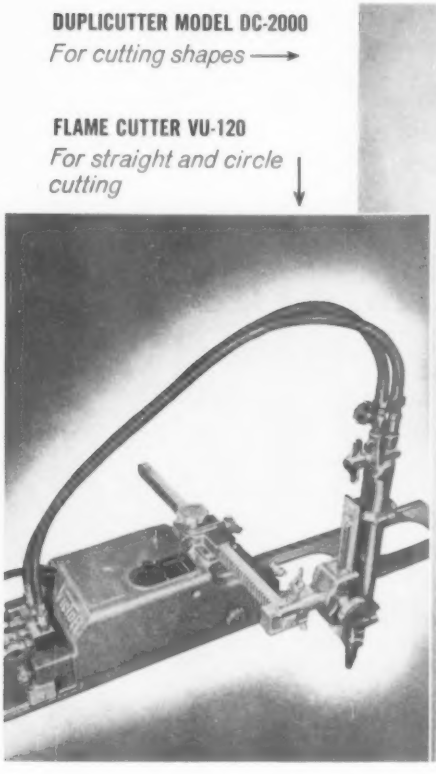

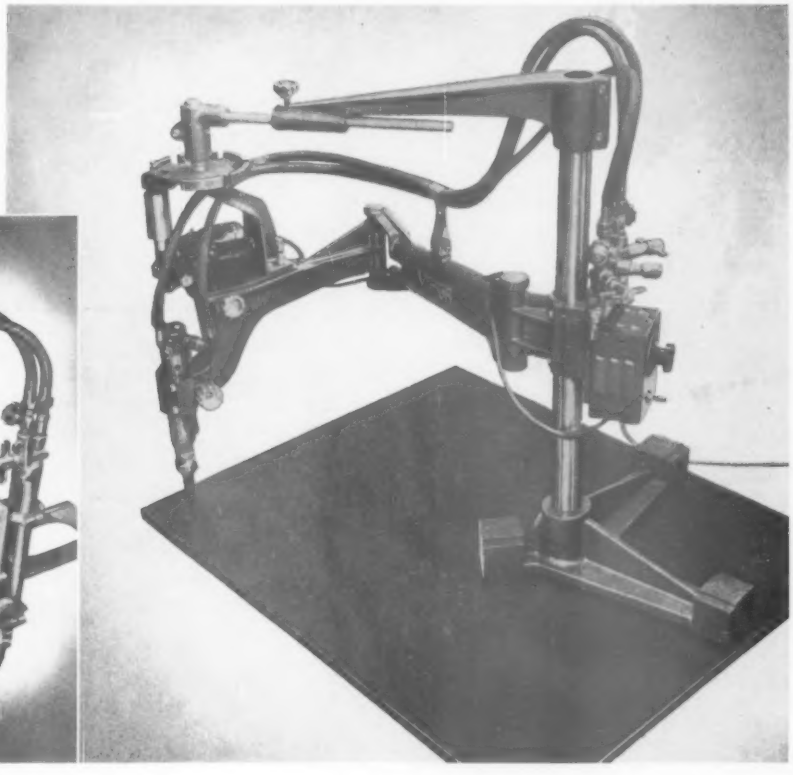

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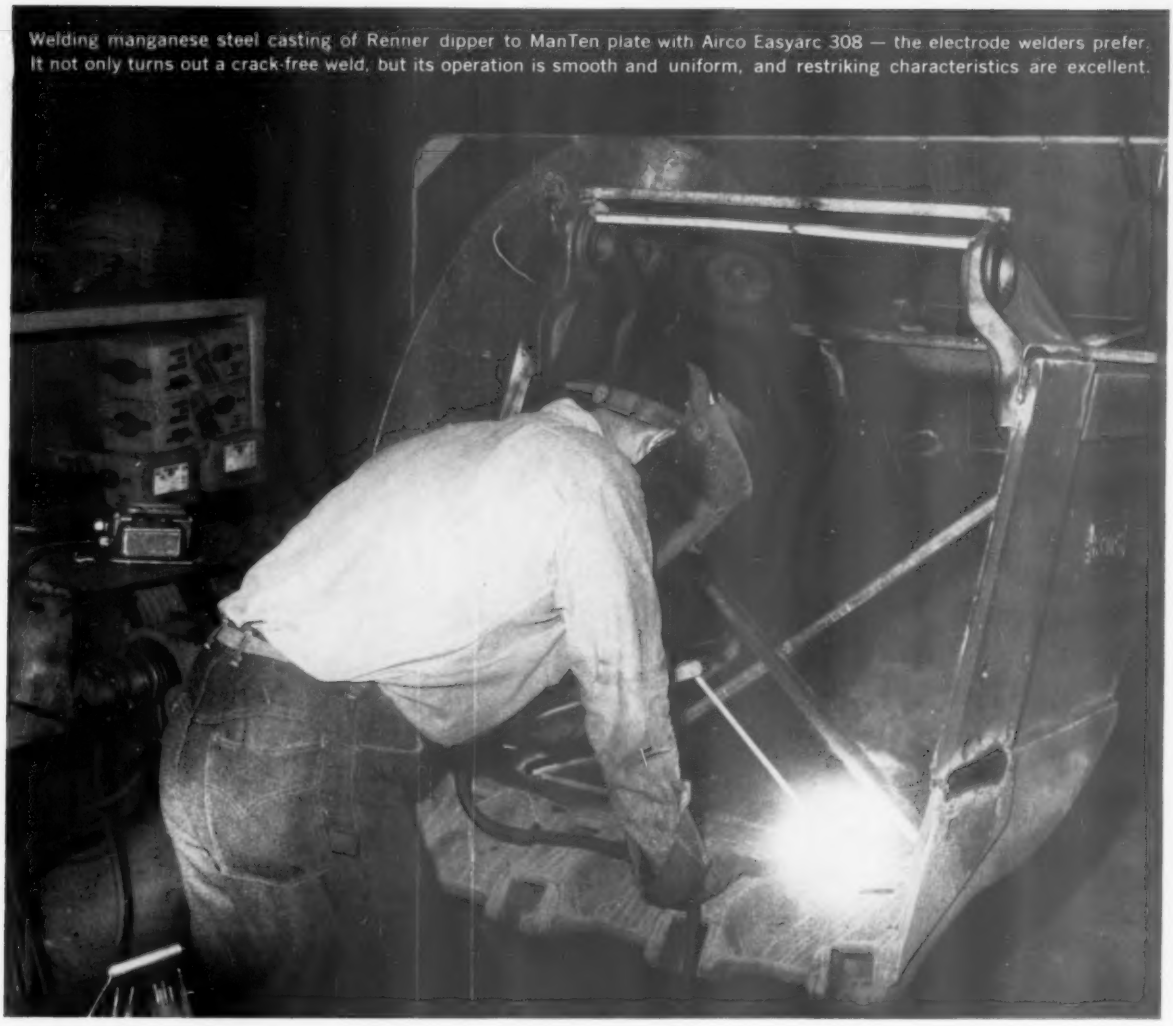

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